

**U.S. Army Corps of Engineers
New England Division
Contract DACA33-91-D-007
Delivery Order Number 7**

Site Investigation Report

**Topsfield Launch Site BO-05
Topsfield/Danvers, Massachusetts**

MADEP Release Tracking Number 3-4136

May 1998

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
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1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE May 1998		3. REPORT TYPE AND DATES COVERED Final (1994-1998)
4. TITLE AND SUBTITLE Site Investigation Report, Topsfield Launch Site BO-05, Topsfield/Danvers, Massachusetts MADEP Release Tracking Number 3-4136 (includes Appendices A-D), Response Action Outcome Statements for RTN's 3-4136 & 3-12607			5. FUNDING NUMBERS Contract No. DACA33-91-D007 Delivery Order Number 7	
6. AUTHOR(S) Metcalf & Eddy, Inc. Martha Zirbel, Project Manager and License Site Professional 781-224-6198				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Metcalf & Eddy, Inc. 30 Harvard Mill Square Wakefield, Massachusetts 01880			8. PERFORMING ORGANIZATION REPORT NUMBER N/A	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Corps of Engineers, New England District 696 Virginia Road Concord, Massachusetts 01742-2751			10. SPONSORING/MONITORING AGENCY REPORT NUMBER N/A	
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12a. DISTRIBUTION AVAILABILITY STATEMENT copy sent to: Massachusetts Department of Environmental Protection Northeast Regional Office 205A Lowell Street Wilmington, Massachusetts 01887			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) The Response Action Outcome (RAO) Statement was done for CENAE in accordance with the Massachusetts Contingency Plan. The RAO Statement consists of the RAO Report, the Site Investigation Report, and DEP form BWSC-104, all included herewith. It addresses site contamination that resulted from a release of diesel fuel oil from two previous underground storage tanks and chlorinated volatile organic compounds in groundwater. The RAO Statement documents that a level of No Significant Risk has been achieved at the site and no further response actions are required.				
14. SUBJECT TERMS			15. NUMBER OF PAGES 180	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT UL	



RESPONSE ACTION OUTCOME (RAO) STATEMENT &
DOWNGRAIDENT PROPERTY STATUS TRANSMITTAL FORM

Pursuant to 310 CMR 40.0180 (Subpart B), 40.0580 (Subpart E) & 40.1056 (Subpart J)

Release Tracking Number

3 - 4136

A. SITE OR DOWNGRAIDENT PROPERTY LOCATION:

Site Name: (optional) Topsfield Launch Site BO-05

Street: U.S. Highway 1

Location Aid: 1/2 mile north of Danvers town line

City/Town: Topsfield

ZIP Code: 01983

☒ Check here if this Site location is Tier Classified. If a Tier I Permit has been issued, state the Permit Number _____

Related Release Tracking Numbers that this Form Addresses 3-12607

If submitting an RAO Statement, you must document the location of the Site or the location and boundaries of the Disposal Site subject to this Statement. If submitting an RAO Statement for a PORTION of a Disposal Site, you must document the location and boundaries for both the portion subject to this submittal and, to the extent defined, the entire Disposal Site. If submitting a Downgradient Property Status Submittal, you must provide a site plan of the property subject to the submittal and, to the extent defined, the Disposal Site.

B. THIS FORM IS BEING USED TO: (check all that apply)

☒ Submit a Response Action Outcome (RAO) Statement (complete Sections A, B, C, D, E, F, H, I, J and L).

☐ Check here if this is a revised RAO Statement. Date of Prior Submittal: _____

☐ Check here if any Response Actions remain to be taken to address conditions associated with any of the Releases whose Release Tracking Numbers are listed above. This RAO Statement will record only an RAO-Partial Statement for those Release Tracking Numbers.

Specify Affected Release Tracking Numbers: _____

☐ Submit an optional Phase I Completion Statement supporting an RAO Statement or Downgradient Property Status Submittal (complete Sections A, B, H, I, J, and L).

☐ Submit a Downgradient Property Status Submittal (complete Sections A, B, G, H, I, J and K).

☐ Check here if this is a revised Downgradient Property Status Submittal. Date of Prior Submittal: _____

☐ Submit a Termination of a Downgradient Property Status Submittal (complete Sections A, B, I, J and L).

☐ Submit a Periodic Review Opinion evaluating the status of a Temporary Solution (complete Sections A, B, H, I, J and L).

Specify one: ☐ For a Class C RAO ☐ For a Waiver Completion Statement indicating a Temporary Solution

Provide Submittal Date of RAO Statement or Waiver Completion Statement: _____

You must attach all supporting documentation required for each use of form indicated, including copies of any Legal Notices and Notices to Public Officials required by 310 CMR 40.1400.

C. DESCRIPTION OF RESPONSE ACTIONS: (check all that apply)

☐ Assessment and/or Monitoring Only

☒ Removal of Contaminated Soils

☒ Re-use, Recycling or Treatment

☐ On Site ☒ Off Site Est. Vol.: 133 cubic yards

Describe: _____

☐ Landfill ☐ Cover ☐ Disposal Est Vol.: _____ cubic yards

☒ Removal of Drums, Tanks or Containers

Describe: one 500-gallon UST; one 2000 gallon UST

☐ Removal of Other Contaminated Media

Specify Type and Volume: _____

☐ Other Response Actions

Describe: _____

☐ Deployment of Absorbant or Contaminant Materials

☐ Temporary Covers or Caps

☐ Bioremediation

☐ Soil Vapor Extraction

☐ Structure Venting System

☐ Product or NAPL Recovery

☐ Groundwater Treatment Systems

☐ Air Sparging

☐ Temporary Water Supplies

☐ Temporary Evacuation or Relocation of Residents

☐ Fencing and Sign Posting

SECTION C IS CONTINUED ON THE NEXT PAGE.



Massachusetts Department of Environmental Protection
Bureau of Waste Site Cleanup

BWSC-104

RESPONSE ACTION OUTCOME (RAO) STATEMENT &
DOWNGRADE PROPERTY STATUS TRANSMITTAL FORM

Release Tracking Number

Pursuant to 310 CMR 40.0180 (Subpart B), 40.0530 (Subpart E) & 40.1056 (Subpart J)

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C. DESCRIPTION OF RESPONSE ACTIONS: (continued)

Check here if any Response Action(s) that serve as the basis for this RAO Statement involve the use of Innovative Technologies. (DEP is interested in using this information to create an Innovative Technologies Cleanhouse.)

Describe Technologies:

D. TRANSPORT OF REMEDIATION WASTE: (If Remediation Waste was sent to an off-site facility, answer the following questions)

Name of Facility Brox Paving Materials Facility (Brox Recycling Facility)

Town and State Marlborough, MA

Quantity of Remediation Waste Transported to Date: 133 cubic yards

E. RESPONSE ACTION OUTCOME CLASS:

Specify the Class of Response Action Outcome that applies to the Site or Disposal Site. Select ONLY one Class:

☐ Class A-1 RAO: Specify one of the following:

☐ Contamination has been reduced to background levels. ☐ A Threat of Release has been eliminated.

☒ Class A-2 RAO: You MUST provide justification that reducing contamination to background levels is infeasible.

☐ Class A-3 RAO: You MUST provide both an implemented Activity and Use Limitation (AUL) and justification that reducing contamination to background levels is infeasible.

If applicable, provide the earlier of the AUL expiration date or date the design life of the remedy will end: _____

☐ Class B-1 RAO: Specify one of the following:

☐ Contamination is consistent with background levels ☐ Contamination is NOT consistent with background levels.

☐ Class B-2 RAO: You MUST provide an implemented AUL.

If applicable, provide the AUL expiration date: _____

☐ Class C RAO: ☐ Check here if you will conduct post-RAO Operation, Maintenance and Monitoring at the Site.

Specify One: ☐ Passive Operation and Maintenance ☐ Monitoring Only

☐ Active Operation and Maintenance (defined at 310 CMR 40.0006)

F. RESPONSE ACTION OUTCOME INFORMATION:

☐ If an RAO Compliance Fee is required, check here to certify that the fee has been submitted. You MUST attach a photocopy of the payment.

☐ Check here if submitting one or more AULs. You must attach an AUL Transmittal Form (BWSC-113) and a copy of each implemented AUL related to this RAO Statement. Specify the type of AUL(s) below: (required for all Class A-3 RAOs and Class B-2 RAOs)

☐ Notice of Activity and Use Limitation ☐ Grant of Environmental Restriction Number of AULs attached: _____

Specify the Risk Characterization Method(s) used to achieve the RAO described above and all Soil and Groundwater Categories applicable to the Site.

More than one Soil Category and more than one Groundwater Category may apply at a Site.
Be sure to check off all APPLICABLE categories, even if more stringent soil and groundwater standards were met.

Risk Characterization Method(s) Used: ☐ Method 1 ☐ Method 2 ☒ Method 3

Soil Category(ies) Applicable: ☒ S-1 ☒ S-2 ☒ S-3

Groundwater Category(ies) Applicable: ☐ GW-1 ☐ GW-2 ☒ GW-3

> When submitting any Class A-1 RAO or a Class B-1 RAO where contamination is consistent with background levels, do NOT specify a Risk Characterization Method.

> When submitting any Class A-2 RAO or a Class B-1 RAO where contamination is NOT consistent with background levels, you cannot use an AUL to maintain a level of no significant risk. Therefore, you must meet S-1 Soil Standards, if using Risk Characterization Method 1.



RESPONSE ACTION OUTCOME (RAO) STATEMENT &
DOWNGRADIANT PROPERTY STATUS TRANSMITTAL FORM

Pursuant to 310 CMR 40.0180 (Subpart S), 40.0580 (Subpart E) & 40.1056 (Subpart J)

Release Tracking Number

3 - 4136

G. DOWNGRADIANT PROPERTY STATUS SUBMITTAL:

- ☐ If a Downgradient Property Status Submittal Compliance Fee is required, check here to certify that the fee has been submitted. You MUST attach a photocopy of the payment.
- ☐ Check here if a Release(s) of Oil or Hazardous Material(s), other than that which is the subject of this submittal, has occurred at this property.
- Release Tracking Number(s) _____
- ☐ Check here if the Releases identified above require further Response Actions pursuant to 310 CMR 40.0000.
- Required documentation for a Downgradient Property Status Submittal includes, but is not limited to, copies of notices provided to owners and operators of both upgradient and downgradient abutting properties and of any known or suspected source properties.

H. LSP OPINION:

I attest under the pains and penalties of perjury that I have personally examined and am familiar with this transmittal form, including any and all documents accompanying this submittal. In my professional opinion and judgment based upon application of (i) the standard of care in 309 CMR 4.02(1), (ii) the applicable provisions of 309 CMR 4.02(2) and (3), and (iii) the provisions of 309 CMR 4.03(5), to the best of my knowledge, information and belief,

> if Section B indicates that a Downgradient Property Status Submittal is being provided, the response action(s) that is (are) the subject of this submittal (i) has (have) been developed and implemented in accordance with the applicable provisions of M.G.L. c. 21E and 310 CMR 40.0000, (ii) is (are) appropriate and reasonable to accomplish the purposes of such response action(s) as set forth in 310 CMR 40.0183(2)(b), and (iii) complies(y) with the identified provisions of all orders, permits, and approvals identified in this submittal;

> if Section B indicates that either an RAO Statement, Phase I Completion Statement and/or Periodic Review Opinion is being provided, the response action(s) that is (are) the subject of this submittal (i) has (have) been developed and implemented in accordance with the applicable provisions of M.G.L. c. 21E and 310 CMR 40.0000, (ii) is (are) appropriate and reasonable to accomplish the purposes of such response action(s) as set forth in the applicable provisions of M.G.L. c. 21E and 310 CMR 40.0000, and (iii) complies(y) with the identified provisions of all orders, permits, and approvals identified in this submittal.

I am aware that significant penalties may result, including, but not limited to, possible fines and imprisonment, if I submit information which I know to be false, inaccurate or materially incomplete.

- ☐ Check here if the Response Action(s) on which this opinion is based, if any, are (were) subject to any order(s), permit(s) and/or approval(s) issued by DEP or EPA. If the box is checked, you MUST attach a statement identifying the applicable provisions thereof.

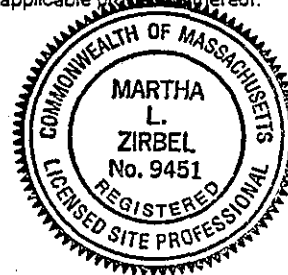
LSP Name: Martha L. Zirbel LSP #: 9451 Stamp:

Telephone: 781-224-6198 Ext.: _____

FAX: (optional) 781-245-6293

Signature: Martha L. Zirbel

Date: 6/3/98



I. PERSON MAKING SUBMITTAL:

Name of Organization: U. S. Army Corps of Engineers, New England District

Name of Contact: H. Farrell McMillan Title: Chief, Engineering/Planning

Street: 696 Virginia Road Division

City/Town: Concord State: MA ZIP Code: 01742-2751

Telephone: (978) 318-8500 Ext.: _____ FAX: (optional) _____

J. RELATIONSHIP TO SITE OF PERSON MAKING SUBMITTAL: (check one)

☐ RP or PRP Specify ☐ Owner ☐ Operator ☐ Generator ☐ Transporter Other RP or PRP _____

☐ Fiduciary, Secured Lender or Municipality with Exempt Status (as defined by M.G.L. c. 21E, s. 2)

☐ Agency or Public Utility on a Right of Way (as defined by M.G.L. c. 21E, s. 5(j))

☒ Any Other Person Submitting This Form Specify Relationship: Assuming responsibility for the previous owner/operator, the U. S. Army



**RESPONSE ACTION OUTCOME (RAO) STATEMENT &
DOWNGRAIDENT PROPERTY STATUS TRANSMITTAL FORM**

Pursuant to 310 CMR 40.0180 (Subpart B), 40.0580 (Subpart E) & 40.1056 (Subpart J)

Release Tracking Number

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K. CERTIFICATION OF PERSON SUBMITTING DOWNGRAIDENT PROPERTY STATUS SUBMITTAL:

I, _____, attest under the pains and penalties of perjury (i) that I have personally examined and am familiar with the information contained in this submittal, including any and all documents accompanying this transmittal form; (ii) that, based on my inquiry of the/those individual(s) immediately responsible for obtaining the information, the material information contained herein is, to the best of my knowledge, information and belief, true, accurate and complete; (iii) that, to the best of my knowledge, information and belief, I/the person(s) or entity(ies) on whose behalf this submittal is made satisfy(ies) the criteria in 310 CMR 40.0183(2); (iv) that I/the person(s) or entity(ies) on whose behalf this submittal is made have provided notice in accordance with 310 CMR 40.0183(5); and (v) that I am fully authorized to make this attestation on behalf of the person(s) or entity(ies) legally responsible for this submittal. I/the person(s) or entity(ies) on whose behalf this submittal is made is/are aware that there are significant penalties, including, but not limited to, possible fines and imprisonment, for willfully submitting false, inaccurate or incomplete information.

By: _____ Title: _____
(signature)

For: _____ Date: _____
(print name of person or entity recorded in Section I)

Enter address of the person providing certification, if different from address recorded in Section I:

Street: _____

City/Town: _____ State: _____ ZIP Code: _____

Telephone: _____ Ext.: _____ FAX: (optional) _____

L. CERTIFICATION OF PERSON MAKING SUBMITTAL:

If you are completing only a Downgradient Property Status Submittal, you do not need to complete this section of the form.

I, H. Farrell McMillan, attest under the pains and penalties of perjury (i) that I have personally examined and am familiar with the information contained in this submittal, including any and all documents accompanying this transmittal form; (ii) that, based on my inquiry of those individuals immediately responsible for obtaining the information, the material information contained in this submittal is, to the best of my knowledge and belief, true, accurate and complete, and (iii) that I am fully authorized to make this attestation on behalf of the entity legally responsible for this submittal. I/the person or entity on whose behalf this submittal is made am/is aware that there are significant penalties, including, but not limited to, possible fines and imprisonment, for willfully submitting false, inaccurate, or incomplete information.

By: H. Farrell McMillan Title: Chief, Engineering/Planning
(signature) Division

For: U. S. Army Corps of Engineers Date: 5-28-98
(print name of person or entity recorded in Section I)

Enter address of the person providing certification, if different from address recorded in Section I:

Street: _____

City/Town: _____ State: _____ ZIP Code: _____

Telephone: _____ Ext.: _____ FAX: (optional) _____

YOU MUST COMPLETE ALL RELEVANT SECTIONS OF THIS FORM OR DEP MAY RETURN THE DOCUMENT AS INCOMPLETE. IF YOU SUBMIT AN INCOMPLETE FORM, YOU MAY BE PENALIZED FOR MISSING A REQUIRED DEADLINE, AND YOU MAY INCUR ADDITIONAL COMPLIANCE FEES.

GENERAL STATEMENT OF LIMITATIONS AND CONDITIONS
ATTACHMENT TO
OPINION OF MASSACHUSETTS LICENSED SITE PROFESSIONAL

METCALF & EDDY, INC.

Name of Licensed Site Professional Martha L. Zirbel
LSP Registration Number 9451
Date of Opinion 6/3, 1998
Client to Whom Opinion was Rendered U. S. Army Corps of Engineers
Date of Agreement between Metcalf & Eddy, Inc. and Client pursuant to which Opinion was Rendered:
March 28, 1994
Response Tracking No./Site No. 3-4136

This Statement of Limitations and Conditions is an integral part of, and is incorporated by reference into, the Opinion of Massachusetts Licensed Site Professional referenced above.

LIMITATIONS

1. Purpose of Opinion

- A. This Opinion is being provided in compliance with the requirements set forth in the Massachusetts Contingency Plan ("MCP"), 310 CMR 40.0000 et seq. Specifically, the LSP has prepared this Opinion at the request of the Client identified above as part of a Response Action Outcome Statement (Insert Appropriate Form-e.g. Release Notification Form, Status Opinion, Completion Statement, Response Action Outcome Statement, Tier Classification Submittal, etc.). This stated purpose has been a significant factor in determining the scope and level of services required to render this Opinion.
- B. Should the purpose for which this Opinion is to be used change, this Opinion shall no longer be valid.

2. General

- A. This Opinion was prepared for the sole and exclusive use of the Client, subject to the provisions of the MCP. No other party is entitled to rely in any way on the conclusions, observations, specifications, or data contained herein without the express written consent of Metcalf & Eddy and the LSP who rendered this opinion. Any use of this Opinion by anyone other than Client, or any use of this Opinion by Client or others for any purpose other than the stated purpose set forth above, without the LSP's review and the written authorization of Metcalf & Eddy and the LSP, shall be at the user's sole risk, and neither Metcalf & Eddy nor the LSP shall have any liability or responsibility therefor.
- B. This Opinion was prepared pursuant to an Agreement between Metcalf & Eddy, Inc. and the Client referenced above which defines the scope of work and sets out agreements regarding waivers of consequential damages, limitations on liability, and other important conditions and restrictions pursuant to which the Opinion is rendered. All uses of the Opinion are subject to and deemed acceptance of the conditions and restrictions contained in such Agreement. A copy of the Agreement or relevant excerpts from the Agreement will be made available upon request to any authorized person seeking to use the Opinion.

3. Scope of Service

The observations and conclusions described in this Opinion are based solely on the Services provided pursuant to the Agreement with the Client and any approved additional services authorized by Client.

Without limitation of any other applicable limitations or conditions, neither Metcalf & Eddy nor the LSP shall be liable for the existence of any condition, the discovery of which would have required the performance of services not authorized under the Agreement.

4. Changed Circumstances

The passage of time may result in changes in technology, economic conditions or regulatory standards, manifestations of latent conditions, or the occurrence of future events which would render this Opinion inaccurate or otherwise inapplicable. Neither Metcalf & Eddy nor the LSP shall be liable or responsible for the consequences of any such changed circumstances or conditions on the accuracy of this Opinion.

5. Should Metcalf & Eddy or the LSP be required or requested to review or authorize others to use this Opinion after its date of submission, Metcalf & Eddy shall be entitled to additional compensation at then existing rates or such other terms as may be agreed upon between Metcalf & Eddy and the Client. Nothing herein contained shall be deemed to require Metcalf & Eddy or the LSP to undertake any such review or authorize others to use this Opinion.

6. The conclusions stated in this Opinion are based upon [check and initial appropriate boxes]:

- ☒ Visual inspection of existing physical conditions;
- ☒ Review and interpretation of site history and site usage information which was made available or obtained within the scope of work authorized by the Client;
- ☒ Information provided by the Client;
- ☒ Information and/or analyses for designated substances or parameters provided by an independent testing service or laboratory on a limited number of samples;
- ☒ A limited number of subsurface explorations made on dates indicated in documentation supporting this Opinion;

☐ Other _____

upon which the LSP has relied and presumed accurate, and upon which the LSP is entitled to reasonably rely. The LSP was not authorized and did not attempt to independently verify the accuracy or completeness of information or materials received from the Client and/or from laboratories and other third parties during the performance of its services. Neither Metcalf & Eddy nor the LSP shall be liable for any condition, information, or conclusion, the discovery of which required information not available to the LSP or for independent investigation of information provided to the LSP by the Client and/or independent third parties.

7. This Opinion is rendered for the limited purpose stated above, and is not and should not be deemed to be an opinion concerning the compliance of any past or present owner or operator of the site with any federal, state or local law or regulation. NO WARRANTY OR GUARANTEE, WHETHER EXPRESS OR IMPLIED, IS MADE BY THIS OPINION, AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE ARE EXPRESSLY DISCLAIMED. Without limiting the generality of the foregoing, no warranty or guarantee is made that all contamination at a site or sources or contamination will be detected or identified, that any action or recommended action will achieve all of its objectives, or that this Opinion or any action as to which this Opinion relates will be upheld by any audit conducted by the DEP or any other party.

U.S. Army Corps of Engineers
New England Division
Contract DACA33-91-D-0007
Delivery Order Number 7

RESPONSE ACTION OUTCOME REPORT

Topsfield Launch Site BO-05
Topsfield/Danvers, Massachusetts
MADEP Release Tracking Number 3-4136

May 1998

Prepared by:
Metcalf & Eddy, Inc.
30 Harvard Mill Square
Wakefield, MA 01880

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1.0 INTRODUCTION

This Response Action Outcome (RAO) Report was prepared by Metcalf & Eddy, Inc., contractor to the U.S. Army Corps of Engineers (USACOE), to summarize response actions at a disposal site located at the former Topsfield Launch Site BO-05, in Topsfield and Danvers, Massachusetts, and provide the necessary documentation that a Class A-2 RAO has been achieved. The disposal site is identified and tracked by the Massachusetts Department of Environmental Protection (MADEP) as Release Tracking Number (RTN) 3-4136. This RAO report, as more specifically detailed in Section 3.0, describes the effectiveness of response actions and remedial investigations that were conducted at the disposal site in order to reduce and evaluate the risk of harm to health, safety, public welfare, and the environment. In addition, this RAO Report includes as a separately bound attachment the Site Investigation Report (M&E, 1998).

The disposal site currently tracked by RTN 3-4136 previously was tracked as two sites. The first of the two sites consisted of the release of an undefined amount of diesel fuel oil from two underground storage tanks on the property. These USTs and their contents, as well as limited amounts of petroleum contaminated soil excavated from the vicinity of the tanks, were removed from the property in 1991 as part of site closure activities under the Defense Environmental Restoration Program (DERP). Because residual soil contamination was shown to remain following DERP activities, MADEP issued USACOE a Notice of Responsibility (NOR) in November 1991 and identified the site as MADEP Location to be Investigated (LTBI) 3-4136. Subsequent investigations associated with LTBI 3-4136 revealed the presence of chlorinated volatile organic compounds (VOCs) in groundwater in an isolated area of the property, a distinctly separate release from the petroleum releases already documented. As a result, USACOE notified MADEP, which issued another NOR in July 1995 identifying a second site, RTN 3-12607. In June 1996, USACOE submitted a Phase I Report and Tier II Classification addressing both sites. As a result, the two sites are currently tracked together as one disposal site under RTN 3-4136.

This RAO Report has been prepared in accordance with the requirements of the Massachusetts Contingency Plan (310 CMR 40.0000, the MCP). Specifically, it complies with Section 40.1056(2) which requires the following:

40.1056: Content of Response Action Outcome Statements

...

(2) Except where previously submitted, all documentation, plans and/or reports necessary to support the Response Action Outcome shall be submitted to the Department, including, without limitation, the following:

- (a) as specified in 310 CMR 40.1003(4), a clear and accurate description of the location of the site or the location and boundaries of the disposal site or portion of disposal site to which the RAO applies. Such description shall reference, to the extent practicable, the location of the site, and location and boundaries of the disposal site or portion thereof relative to permanent or semi-permanent landmarks, and/or surveyed boundaries;*
- (b) for all Class A Response Action Outcomes and where applicable to Class C Response Action Outcomes, a demonstration that all uncontrolled sources, as specified in 310 CMR 40.1003(5) have been eliminated or controlled;*
- (c) for all Class A and B Response Action Outcomes, information supporting the conclusion that a level of No Significant Risk has been achieved or exists;*
- (d) for all Class C Response Action Outcomes, information supporting the conclusion that no substantial hazards remain for the disposal site;*
- (e) for all Class A Response Action Outcomes, information documenting the extent to which levels of oil and/or hazardous material in the environment have been reduced to background, and for all Class A-2 and A-3 RAOs, the results of the feasibility evaluation conducted pursuant to 310 CMR 40.0860 demonstrating that the achievement of background is not feasible;*
- (f) for all Class A-4 and B-3 Response Action Outcomes, the results of the evaluation conducted pursuant to 310 CMR 40.0860 demonstrating that the achievement of Upper Concentration Limits in Soil located at a depth greater than fifteen feet from the ground surface or in the area beneath an engineered barrier is not feasible;*
- (g) a copy of any and all Activity and Use Limitations certified by the appropriate registry of deeds or land registration office which have been implemented under 310 CMR 40.1070;*

(h) where the RAO is based upon the implementation of an Activity and Use Limitation, an Activity and Use Limitation Opinion accompanied by an Activity and Use Limitation Opinion form prescribed by the Department as specified in 310 CMR 40.1071 or 310 CMR 40.1074, whichever is applicable;

(i) a description of any operation, maintenance, and/or monitoring that will be required to confirm and/or maintain those conditions at the disposal site upon which the RAO is based; and

(j) for all Class C Response Action Outcomes, a copy of the plan, as specified in 310 CMR 40.0861(2)(h), which presents definitive and enterprising steps to be taken toward achieving a Permanent Solution at the disposal site.

As demonstrated in this report and the Site Investigation Report (M&E, 1998), a Permanent Solution has been achieved at the disposal site. Response actions consisting of removal and disposal of two USTs and associated petroleum contaminated soil have been performed (i.e., under the DERP in 1991). Although the level of oil and hazardous material has not been reduced to background, a level of No Significant Risk has been achieved. Further, Activity and Use Limitations are not required to maintain No Significant Risk. A Class A-2 RAO applies to the disposal site. Therefore, Sections 40.1056(2)(d), (f), (g), (h) and (j) are not applicable to the disposal site. The remaining sections of 40.1056(2) are applicable, and are addressed in this report.

2.0 SITE LOCATION/BOUNDARIES

40.1056(2)(a) as specified in 310 CMR 40.1003(4), a clear and accurate description of the location of the site or the location and boundaries of the disposal site or portion of disposal site to which the RAO applies. Such description shall reference, to the extent practicable, the location of the site, and location and boundaries of the disposal site or portion thereof relative to permanent or semi-permanent landmarks, and/or surveyed boundaries;

The former Topsfield Launch Site BO-05 consists of approximately 18 acres, and is located in the towns of Topsfield and Danvers, Massachusetts. Access to the property is from U.S. Highway 1, approximately one-half mile north of the Topsfield/Danvers corporate boundary. The disposal site is a significantly smaller, isolated area located entirely on the property. The RAO addressed by

this report applies to the entire disposal site. The geographic location of the property and the boundaries of the disposal site are shown on Figures 2-1 and 2-2, respectively, of the Site Investigation Report (M&E, 1998). Copies of these figures are provided in Appendix A of this report.

The disposal site was defined based on the location of the releases that triggered response actions as well as the results of site investigations. The fuel oil releases occurred from USTs that were previously located behind the barracks building and the missile assembly and test building. The chlorinated VOCs were identified in groundwater behind the missile assembly and test building. Field investigations consisting of sampling and analysis of soil, groundwater and soil gas has helped to define the limits of the contamination. As shown on Figure 2-2 in Appendix A, the disposal site encompasses a contiguous area consisting of approximately a 100-foot radial area around the previous location of UST-1 (including the southeastern half of the barracks building); approximately a 75-foot radial area around the previous location of UST-2 (including the entire missile assembly and test building), and approximately a 100-foot wide length of land along the sewer and water lines between the radial areas.

3.0 RESPONSE ACTIONS

40.1056(2)(b) for all Class A Response Action Outcomes and where applicable to Class C Response Action Outcomes, a demonstration that all uncontrolled sources, as specified in 310 CMR 40.1003(5) have been eliminated or controlled;

All identified, uncontrolled sources at the disposal site which could have resulted in an increase in concentrations of oil and hazardous materials have been eliminated or controlled.

3.1 Fuel Oil Release from UST-1

UST-1 was a 2,000-gallon tank used for the storage of diesel fuel oil, which was previously located behind the barracks building (KELCO, 1992a). In September 1991, UST-1 was removed

after approximately 14 years of not being in use (USACOE, 1994). During the removal of UST-1, an unknown volume of fuel oil was observed to be present in the tank and oil-stained subsurface soil was visible in the excavation (KELCO, 1991). The source of the fuel oil contamination of subsurface soils in the vicinity of the barracks building is likely to have been caused by leaks from UST-1 over a sustained period of time (KELCO, 1992b; McDowell, 1991).

Approximately 60 cubic yards of contaminated soil was excavated in the vicinity of UST-1; this soil was removed from the disposal site and transported to a recycling facility. Visual observations indicated that not all of the contaminated soil was removed. However, excavation did not continue due to site-specific limitations (KELCO, 1991 and 1992b). Subsequent investigations were conducted in 1991, 1994 and 1996, including soil sampling and analysis, the installation of groundwater monitoring wells, and groundwater sampling and analysis. The results of these investigations show that in the vicinity of the former location of UST-1, subsurface soils (generally at 6-12 feet below grade) contain residual contamination related to the fuel oil release (e.g., total petroleum hydrocarbons or TPH). The results do not indicate elevated contaminant concentrations related to the fuel oil release in groundwater in the vicinity of, or downgradient of, the previous location of UST-1 (M&E, 1998).

The direct source of fuel oil contamination in the vicinity of the previous location of UST-1 has been eliminated by the removal of the tank. In addition, intermedia transfer has been adequately controlled by the removal and off-site disposal of the majority of contaminated soil.

3.2 Fuel Oil Release from UST-2

UST-2 was a 500-gallon tank used for the storage of diesel fuel oil, which was previously located behind the missile assembly and test building (KELCO, 1992a). In September 1991, UST-2 was removed after approximately 14 years of not being in use (USACOE, 1994). During the removal of UST-2, an unknown volume of fuel oil was observed to be present in the tank and oil-stained subsurface soil was visible in the excavation (KELCO, 1991). The source of the fuel oil

contamination of subsurface soils in the vicinity of the missile assembly and test building is likely to have been caused by a discharge from UST-2 (KELCO, 1992b).

Approximately 73 cubic yards of contaminated soil was excavated in the vicinity of UST-2; this soil was removed from the disposal site and transported to a recycling facility. Confirmatory sampling at the completion of the excavation activities indicated the presence of limited areas of residual TPH contamination (KELCO, 1991, 1992b and 1992c). Subsequent investigations were conducted in 1994 and 1996, including soil sampling and analysis, the installation of groundwater monitoring wells, and groundwater sampling and analysis. The results of these investigations show that only low concentrations of TPH remain in isolated areas of subsurface soils. The results do not indicate elevated contaminant concentrations related to the fuel oil release in groundwater in the vicinity of, or downgradient of, the previous location of UST-2 (M&E, 1998).

The direct source of fuel oil contamination in the vicinity of the previous location of UST-2 has been eliminated by the removal of the tank. In addition, intermedia transfer has been adequately controlled by the removal and off-site disposal of the majority of contaminated soil.

3.3 Chlorinated VOCs in Groundwater

During analysis of groundwater samples in 1994 for aromatic volatile hydrocarbons related to the fuel oil releases, chlorinated VOCs were detected but not accurately quantified in groundwater samples collected in the immediate vicinity of the missile assembly and test building. In 1996, a soil vapor survey was conducted to search for a possible source for the chlorinated VOCs in groundwater. None of the compounds of interest were detected in the soil vapor at concentrations exceeding background. However, groundwater sampling and analysis conducted in 1996 confirmed the presence of chlorinated VOCs in the groundwater. The extent of contamination is limited to the upper 34 feet of the aquifer in the immediate vicinity of monitoring well MW-9. Contamination in wells surrounding MW-9 was detected at much lower levels.

The source of chlorinated VOCs in groundwater is likely due to the historical use of various solvents, anti-corrosion products and paints at the missile assembly and test building. The building is no longer in use and no other source was identified that is likely to result in increased concentrations of chlorinated VOCs in soil and groundwater.

4.0 RISK CHARACTERIZATION

40.1056(2)(c) for all Class A and B Response Action Outcomes, information supporting the conclusion that a level of No Significant Risk has been achieved or exists;

The risk of harm to human health, safety, public welfare and the environment was evaluated using MCP Method 3, to determine whether a condition of No Significant Risk exists at the disposal site. The risk evaluation is presented in detail in the Site Investigation Report (M&E, 1998), which is attached to this RAO Report as a separately bound report. As documented in the Site Investigation Report, no risk of harm to human health, welfare, safety, or the environment has been identified for the releases of fuel oil and chlorinated VOCs at the disposal site. A condition of No Significant Risk exists at the disposal site, and AULs are not required to maintain current exposure categories.

5.0 FEASIBILITY OF ACHIEVING OR APPROACHING BACKGROUND

40.1056(2)(e) for all Class A Response Action Outcomes, information documenting the extent to which levels of oil and/or hazardous material in the environment have been reduced to background, and for all Class A-2 and A-3 RAOs, the results of the feasibility evaluation conducted pursuant to 310 CMR 40.0860 demonstrating that the achievement of background is not feasible;

5.1 Chlorinated VOCs in Groundwater

Chlorinated VOCs were detected in groundwater at concentrations above background only in the immediate vicinity of groundwater monitoring well MW-9. The concentrations at MW-9 are considered to be approaching background, since they are several orders of magnitude below the

MCP Method 1 GW-3 standards, and because no current sources of VOCs were found to exist. Further, the concentrations at wells downgradient of MW-9 suggest natural attenuation may be occurring. The incremental cost of implementing a groundwater treatment alternative other than natural attenuation is substantial and disproportionate to the incremental benefit of risk reduction, since a level of No Significant Risk already exists.

5.2 Fuel Oil Releases

The levels of oil and hazardous material at the disposal site related to the fuel oil releases have not been reduced to background. Further, the concentrations of petroleum hydrocarbons are not considered to be approaching background. Therefore, the feasibility of achieving or approaching background has been evaluated in accordance with 310 CMR 40.0860. Based on the evaluation, it can be demonstrated that it is not feasible to achieve or approach background levels. The criteria used to evaluate feasibility of achieving or approaching background include, but are not limited to, technological feasibility, justification of cost, and implementability. Infeasibility based on any one criteria is considered sufficient to conclude that achieving or approaching background is infeasible. For this disposal site, a cost-benefit analysis demonstrates that the incremental cost of conducting further response actions is substantial and disproportionate to the incremental benefit of risk reduction and environmental restoration.

5.2.1 Fuel Oil Release from UST-1. Alternatives to reduce contaminant concentrations from the fuel oil release at UST-1 to background are technically feasible and implementable. The most effective alternative is excavation; transport; and recycling, reuse or disposal of impacted soil. To date, 60 cubic yards of contaminated soil has been excavated from the vicinity of UST-1 and disposed of. Approximately 1,300 cubic yards of contaminated soil is estimated to remain in that area. Up to 3,500 cubic yards of soil may have to be excavated to remove the remaining contaminated soil. The incremental cost of excavating and disposing of this additional soil would not be justified by the incremental benefits.

Fuel oil is relatively biodegradable and is expected to attenuate to levels approaching background in the relatively near future without additional remediation. Excavation and transport activities would generate a substantial volume of contaminated soil as well as unimpacted soil and could result in damage to human health and the environment through dust generation, noise, and potential erosion of disturbed soil. In addition, excavation would occur in the vicinity of an active water main, and could result in damage to the main as well as a temporary interruption of water service to residential users. Finally, site investigations indicate residual contamination is present along the foundation of, and likely beneath, the barracks building. Although this building is in disrepair, there are currently no known plans to demolish the building. With the building in place, the impacted soil located beneath and adjacent to the building could not be removed and background could not be achieved. Excavation, transport and offsite disposal would achieve some incremental reduction in risk for the disposal site. However, since a level of No Significant Risk is achieved without further response actions, any incremental reduction in risk is expected to be small. Therefore, the incremental cost of excavating and disposing of additional soil is substantial and disproportionate to the incremental benefit of risk reduction.

5.2.2 Fuel Oil Release from UST-2. Alternatives to reduce contaminant concentrations from the fuel oil release at UST-2 to background are technically feasible and implementable. The most effective alternative is excavation; transport; and recycling, reuse or disposal of impacted soil. To date, 73 cubic yards of contaminated soil has been excavated from the vicinity of UST-2 and disposed of. Although the volume of contaminated soil remaining in this area is estimated to be no more than the volume already removed, a significant amount of soil (greater than 500 cubic yards) would likely have to be excavated in order to locate and remove the smaller areas of contamination. The incremental cost of excavating and disposing of this additional soil would not be justified by the incremental benefits.

Fuel oil is relatively biodegradable and is expected to attenuate to levels approaching background in the relatively near future without additional remediation. Excavation and transport activities would generate a substantial volume of unimpacted soil for the purpose of removing a

disproportionately small volume of impacted soil, and could result in damage to human health and the environment through dust generation, noise, and potential erosion of disturbed soil. In addition, excavation would occur in the immediate vicinity of an active water main, and could result in damage to the main as well as a temporary interruption of water service to residential users. Excavation, transport and offsite disposal would achieve some incremental reduction in risk for the disposal site. However, since a level of No Significant Risk is achieved without further response actions, any incremental reduction in risk is expected to be small. Therefore, the incremental cost of excavating and disposing of additional soil is substantial and disproportionate to the incremental benefit of risk reduction.

6.0 POST RAO OPERATION, MAINTENANCE, AND MONITORING

40.1056(2)(i) a description of any operation, maintenance, and/or monitoring that will be required to confirm and/or maintain those conditions at the disposal site upon which the RAO is based;

A Permanent Solution has been achieved at the disposal site, resulting in a condition of No Significant Risk. No AULs have been implemented or are necessary to maintain a condition of No Significant Risk. Therefore, post RAO operation, maintenance or monitoring is not required.

7.0 CONCLUSIONS

Based on the information gathered from site investigations and the risk characterization presented in the Site Investigation Report (M&E, 1998), a condition of No Significant Risk of harm to human health, safety, public welfare and the environment has been achieved at the disposal site for both current and future use. No AULs have been implemented or are required to maintain this condition. The concentrations of chlorinated VOCs in groundwater are at levels that approach background. The level of oil and hazardous material at the disposal site related to the fuel oil release has not been reduced to background. However, the feasibility of achieving background conditions has been evaluated and it has been demonstrated that it is not feasible to achieve or

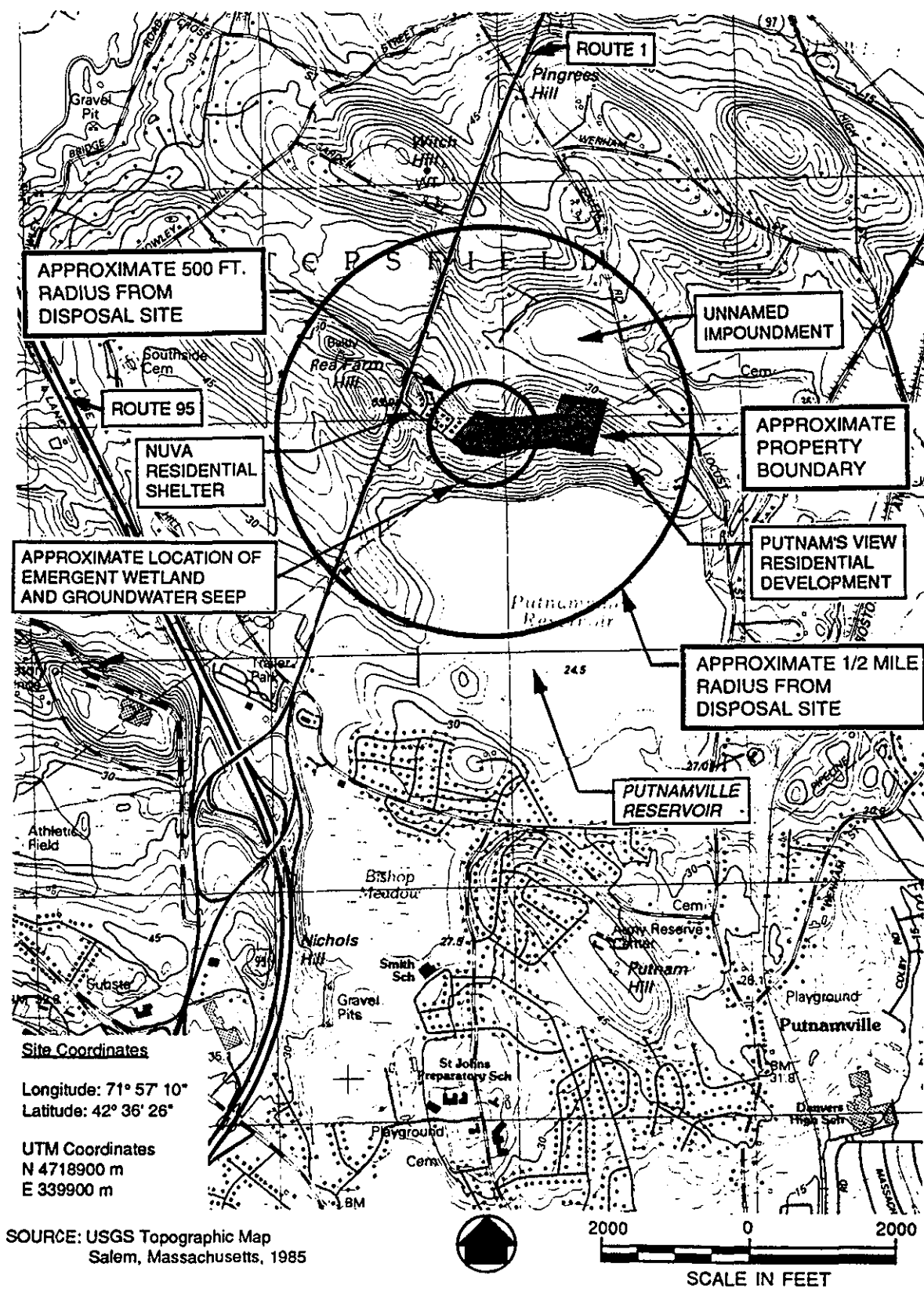
approach background. No further action is necessary to achieve a permanent Response Action Outcome.

In accordance with 310 CMR 40.1036(2), a Class A-2 RAO shall apply to disposal sites where (1) a Permanent Solution has been achieved; (2) the level of oil and hazardous material in the environment has not been reduced to background; and (3) one or more AULs are not required to maintain a level of No Significant Risk. These criteria have been met, and a Class A-2 RAO applies to the disposal site identified as RTN 3-4136.

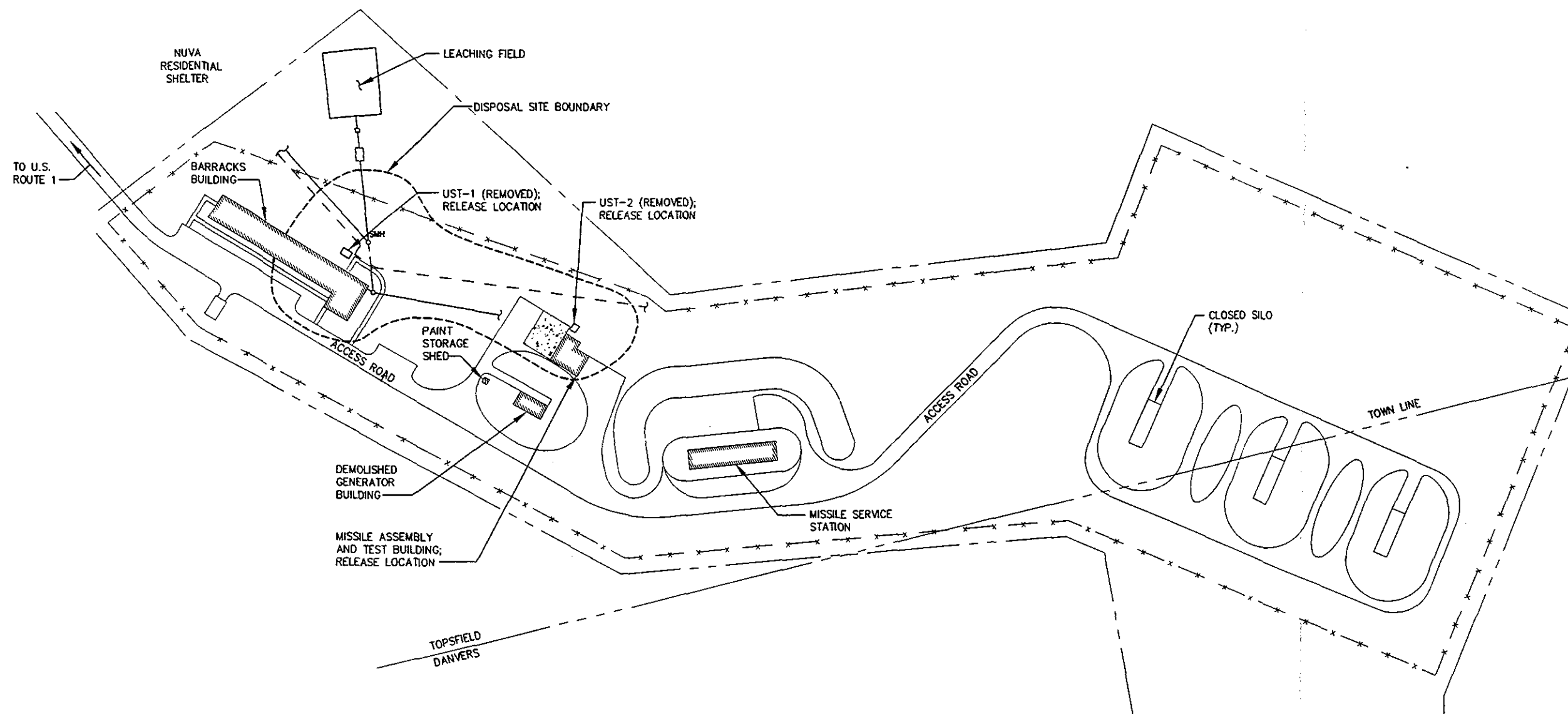
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APPENDIX A
FIGURES



**FIGURE 2-1. LOCUS MAP, TOPSFIELD LAUNCH SITE BO-05
TOPSFIELD/DANVERS, MA**



LEGEND:

- PROPERTY LINE
- x-x- EXIST. FENCE
- APPROX. LOCATION OF SEPTIC/SEWER LINE (INACTIVE)
- APPROX. LOCATION OF WATER LINE (ACTIVE)
- UST-1 APPROX. PREVIOUS LOCATION OF REMOVED UNDERGROUND STORAGE TANK
- DISPOSAL SITE BOUNDARY

NOTE:
PROPERTY PLAN IS BASED IN PART UPON THE 1994 SURVEY BY GUERRIERE & HALNON, INC. AND VARIOUS RECORD DRAWINGS PROVIDED BY USACOE. SOME PROPERTY FEATURES ARE BASED ON VISUAL OBSERVATIONS.

M&E METCALF & EDDY

TOPSFIELD, MASSACHUSETTS

FIGURE 2-2 PROPERTY PLAN

SCALE: 1"=150' 11/1/96 RCP CZTOP001.DWG

**U.S. Army Corps of Engineers
New England Division
Contract DACA33-91-D-007
Delivery Order Number 7**

Site Investigation Report

**Topsfield Launch Site BO-05
Topsfield/Danvers, Massachusetts
MADEP Release Tracking Number 3-4136**

May 1998

**Prepared by:
Metcalf & Eddy, Inc.
30 Harvard Mill Square
Wakefield, MA 01880**

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EXECUTIVE SUMMARY

This report documents and summarizes investigations that have been conducted at the former Topsfield Launch Site BO-05, located in the towns of Topsfield and Danvers, Massachusetts. During investigations and remedial activities conducted from 1987 to 1991, the U.S. Army Corps of Engineers (USACOE) discovered petroleum contaminated soil in the vicinities of two previous underground storage tanks (UST-1 and UST-2). USACOE attempted to excavate the contaminated soil associated with these two releases, but residual soil contamination was shown to remain (USACOE, 1994).

At the direction of USACOE, Metcalf & Eddy conducted additional site investigations in 1994 in accordance with the Massachusetts Contingency Plan. During the 1994 investigations, chlorinated volatile organic compounds (VOCs) were detected in groundwater, constituting a third release unrelated to the two petroleum releases. The three releases were addressed in a Phase I Report and Tier II Classification submitted to MADEP on June 20, 1996. The Phase I Report concluded that no additional response actions were required to address the fuel oil release from UST-2, but additional investigations were required to address the fuel oil release from UST-1 and the chlorinated VOCs in groundwater. These additional response actions had already been initiated at the time the Phase I Report and Tier II Classification were submitted to MADEP.

Based on the information gathered to date and the results of a risk characterization, a condition of No Significant Risk of harm to human health, safety, public welfare and the environment has been achieved, and a Class A-2 Response Action Outcome applies to the disposal site.

1.0 INTRODUCTION

This report is a Site Investigation Report for a disposal site located on the property of the former Topsfield Launch Site BO-05, in the towns of Topsfield and Danvers, Massachusetts. The purpose of this report is to document investigations that have been conducted to date, summarize analytical data generated during these investigations, determine the nature and extent of contamination as exhibited by the data, and provide a risk characterization based upon the data. This report updates the Phase I Report (M&E, 1996) and serves as a supplement to the Response Action Outcome (RAO) Report for the disposal site (M&E, 1998).

The former Topsfield Launch Site BO-05 (i.e., the property) was used as a Department of Defense NIKE Missile Battery from 1955 to 1973. During investigations and remedial activities conducted at the property from 1987 to 1991 under the Defense Environmental Restoration Program, the U.S. Army Corps of Engineers (USACOE) discovered leakage of an undefined amount of fuel oil from two underground storage tanks (USTs). These tanks and their contents, as well as limited amounts of excavated, petroleum-contaminated soil were removed from the property. However, residual soil contamination was shown to remain in the vicinity of the two USTs (USACOE, 1994).

As a result of the remaining soil contamination, the Massachusetts Department of Environmental Protection (MADEP) issued USACOE a Notice of Responsibility (NOR) in November 1991 requiring response actions to investigate and mitigate, as necessary, the fuel oil releases (MADEP Location to be Investigated 3-4136). In accordance with the Massachusetts Contingency Plan (310 CMR 40.0000, the MCP), additional field investigations were conducted in 1994 to define the nature and extent of remaining contamination and determine the need for additional response actions. The results of the 1994 investigation indicated that, in accordance with the MCP, an RAO was likely achievable for the fuel oil release from UST-2, but additional response actions were required for the fuel oil release from UST-1. The 1994 field investigations also revealed the presence of chlorinated volatile

organic compounds (VOCs) in groundwater in an isolated area of the property, at estimated concentrations exceeding MCP Reportable Concentrations. Since this newly discovered release was distinct from the petroleum releases already documented, USACOE notified MADEP of the release; MADEP issued a second NOR in July 1995 (MADEP Release Tracking Number 3-12607). In June 1996, USACOE submitted a Phase I Report and Tier II Classification addressing all three releases (i.e., LTBI 3-4136 and RTN 3-12607). As a result, the three releases are currently tracked together under RTN 3-4136.

In 1996 additional investigations were conducted to define the nature and extent of the groundwater contamination associated with the chlorinated VOCs and the soil contamination associated with the fuel oil release from UST-1. This additional data, together with previous site information, was used to perform a Method 3 risk characterization.

This report provides site-specific information, describes the site investigations conducted to date, presents analytical results, summarizes the nature and extent of contamination at the disposal site, and presents the risk characterization.

2.0 THE DISPOSAL SITE AND SURROUNDING AREA

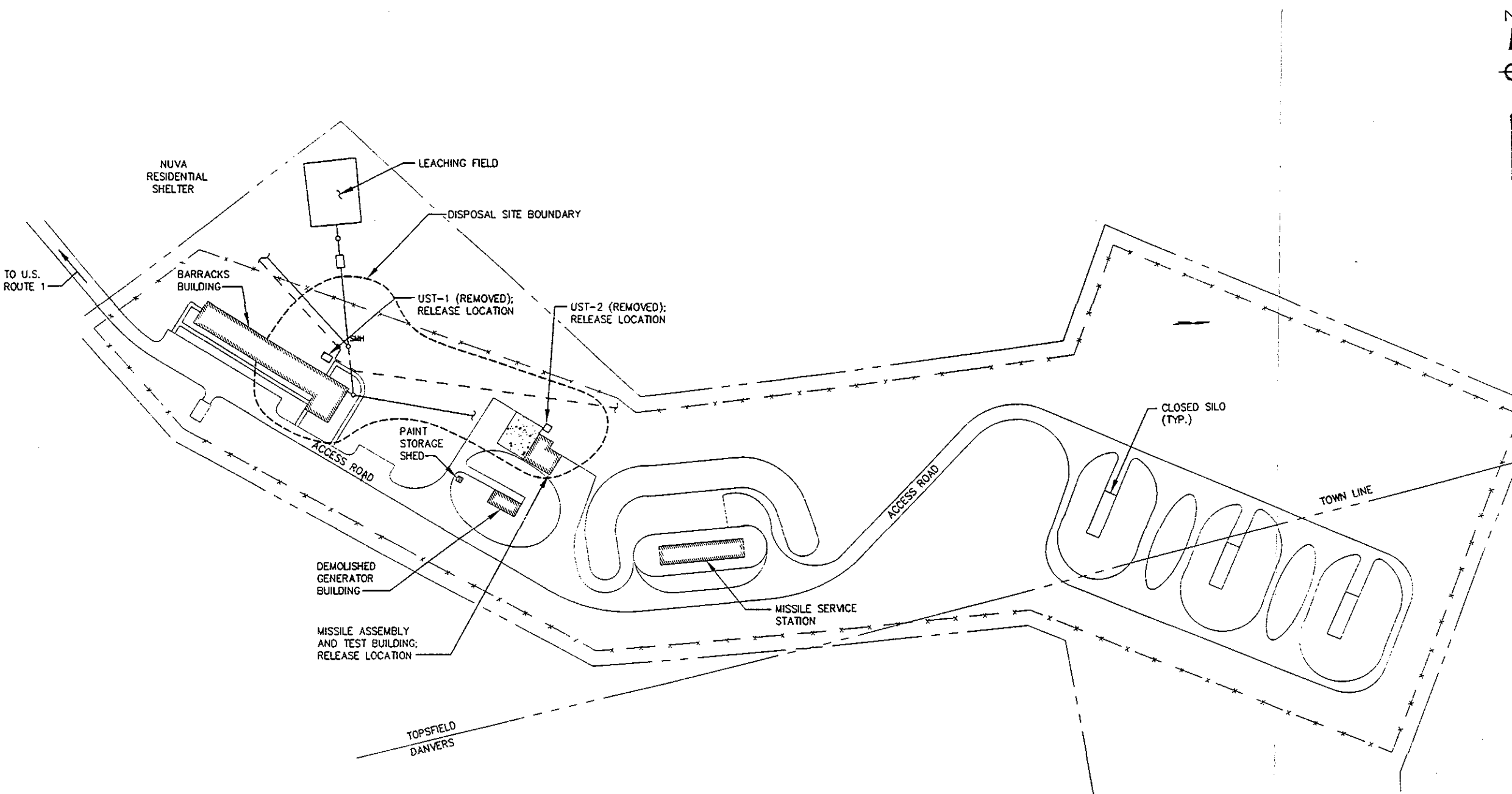
2.1 General Property and Disposal Site Information

The former Topsfield Launch Site BO-05 is located about 20 miles north of Boston, in the towns of Topsfield and Danvers, Massachusetts. Access to the property is from U.S. Highway 1, approximately 1/2 mile north of the Topsfield/Danvers Corporate Boundary. Figure 2-1 depicts the location of the property. The disposal site is a smaller area located on the property. Due to scale, the disposal site boundaries are not shown on Figure 2-1, however, the approximate 500 foot and 1/2 mile radii from the disposal site boundaries are depicted. As shown on Figure 2-1, the Universal Transverse Mercator (UTM) coordinates in the approximate geographical center of the disposal site are N 4718900m and E 339900m, corresponding to a longitude of 71° 57' 10" and a latitude of 42° 36' 26". The location of the disposal site on the property is shown on Figure 2-2. The disposal site is defined as a contiguous area encompassing the location of the releases (i.e., the previous locations of UST-1 and UST-2, and the vicinity of the missile assembly and test building) as well as the areas that have been impacted by those releases. In accordance with the MCP, the focus of this report is on the disposal site, as defined, and not on the entire property. For clarity, the discussions in this report occasionally reference the property as a whole.

The property on which the disposal site is located is a former Department of Defense NIKE missile battery. The facility was constructed in 1955, and remained operational until 1973. The property was subsequently used for a short period of time as an Army Reserve Center, and is currently used solely for watershed protection purposes.

Most of the original facility structures are still present on the property, as shown on Figure 2-2. These structures include: three underground, closed missile silos; a missile service station; a missile assembly and test building; a barracks building; abandoned and active





LEGEND:

- PROPERTY LINE
- x-x- EXIST. FENCE
- APPROX. LOCATION OF SEPTIC/SEWER LINE (INACTIVE)
- APPROX. LOCATION OF WATER LINE (ACTIVE)
- UST-1 APPROX. PREVIOUS LOCATION OF REMOVED UNDERGROUND STORAGE TANK
- DISPOSAL SITE BOUNDARY

NOTE:
PROPERTY PLAN IS BASED IN PART UPON THE 1994 SURVEY BY GUERRIERE & HALNOR, INC. AND VARIOUS RECORD DRAWINGS PROVIDED BY USACOE. SOME PROPERTY FEATURES ARE BASED ON VISUAL OBSERVATIONS.

M&E METCALF & EDDY

TOPSFIELD, MASSACHUSETTS
FIGURE 2-2 PROPERTY PLAN

SCALE: 1"=150' 11/1/96 RCP CZTOP001.DWG

underground utilities; a septic system and leaching field; and various small sheds and minor accessory features. There is also one unidentified building located at the entrance to the property, across from the barracks building. This building has no windows, and its one door is barricaded with soil to prevent access. USACOE has indicated the building may have been constructed as a fall-out shelter, but its actual former use is unknown. Previous activities at the property have included the demolition and/or removal and disposal of various other structures including a generator building and several above ground and underground storage tanks (USACOE, 1994).

The property is surrounded by a chain-link, barbed-wire fence, with an access gate off of Route 1. However, there are several areas around the perimeter of the property where the fence is collapsed or otherwise damaged, allowing for easy unauthorized access onto the property. Further, there are indications that unauthorized access does occur, such as vandalism to the buildings and informal reports made to Metcalf & Eddy by abutters.

2.2 Surrounding Land Use

The entire property, including the disposal site, is currently inactive, and serves only as part of a larger watershed protection area. Therefore, there are no existing onsite workers. There is a developing residential population in the general site vicinity and one abutting property is used as a residential shelter. No institutions have been identified within 500 feet of the disposal site.

The disposal site is completely contained within the property boundaries, which is abutted by nine parcels of land. Unoccupied land to the north is owned by the Salem and Beverly Water Supply Board, and used as a watershed protection area for a possible future reservoir which would be constructed in Topsfield. Five residential lots are located to the east. Two of the five lots are located in Topsfield; the other three lots are situated in Danvers, in a residential development called Putnam's View. Based on a reconnaissance of the surrounding area in

October 1996, single family homes have been constructed on four of these lots; the fifth lot may be developed in the future. The property is abutted to the south by a large residential parcel which had not been developed as of the October 1996 reconnaissance. This lot may also be developed in the future. West of the property is a vacant lot which may be developed in the future and a residential development called NUVA.

The NUVA residential development, formerly called Plowshares, is used as a shelter for the homeless, AIDS patients, and people with damaged homes. NUVA currently leases, under the McKinney Homeless Assistance Act, 8.5 acres of land and 16 three-bedroom houses from the Department of the Army, Army Corps of Engineers. This property was originally the housing portion of the former Topsfield Launch Site until it was separated from the missile site in the mid-seventies. Fourteen of the sixteen homes are available for residences; the remaining two homes serve as an office and storage area (NUVA, 1994).

An identification of residences within a 1/2 mile radius of the disposal site was made based on the USGS map, maps and information available through the town offices, and a visual drive-by reconnaissance survey. In addition to the 14 NUVA residences and the 4 houses on lots abutting the property, approximately 32 other homes have been identified within a 1/2 mile radius of the disposal site. Twenty of these homes are part of the Putnam's View development, seven are along or in the vicinity of Salem Road in Topsfield, four are along Locust Street in Danvers, and one is along Route 1 in Topsfield.

Based on information obtained from the towns, Topsfield and Danvers have a combined population of approximately 30,000 people in 10,000 homes. Therefore, the towns have an average dwelling rate of approximately three residents per home. Applying this average to the 50 homes identified, there may be approximately 150 residents living within a 1/2 mile radius of the disposal site. This estimate is conservative, because it assumes there are 42 residents at the NUVA shelter, which, based on estimates from NUVA staff, typically has fewer residents.

2.3 Natural Resources Evaluation

The natural resources evaluation consisted of a review of available resource mapping and a field survey of the ecological communities and sensitive resource areas on and within 500 ft of the property on which the disposal site is located.

2.3.1 Review of Resource Maps. Resource maps reviewed included the U.S. Geological Survey (USGS) *Topographic Map*, U.S. Fish and Wildlife Service (USFWS) *National Wetlands Inventory Map*, U.S. Department of Agriculture/Soil Conservation Service (USDA/SCS) *Soil Survey of Essex County*, Federal Emergency Management Agency (FEMA) *Flood Insurance Rate Map*, and Massachusetts Natural Heritage and Endangered Species Program (MNHESP) *Atlas of Estimated Habitats of State-Listed Rare Wetlands Wildlife*.

The USGS *Topographic Map* (USGS, 1985) indicates that the property is atop a ridge, flanked by two open water/wetland systems (Figure 2-1). The property and the surrounding area atop the ridge are indicated as developed land. The NUVA residential shelter which abuts the property to the west is also atop the ridge. The steeply sloping topography surrounding the ridge is indicated as woodland. Putnamville Reservoir is located approximately 750 feet south of the property. Surface water runoff flowing southeast from the intersection of Route 1 and the property access road to the northwest corner of the reservoir is apparent from the topographic contours. Approximately 1,000 feet north of the property, a small unnamed impoundment is depicted with a wooded swamp/marsh at its western end. An unnamed perennial stream flows into this small impoundment from several small ponds upstream, then flows from the impoundment into Wenham Swamp at a point approximately 1,000 feet east of Salem Road. Wenham Swamp is located approximately 2,500 feet northeast of the property. No open water, streams or swamp/marsh habitats are depicted on or within 500 feet of the property.

The *National Wetlands Inventory Map* (USFWS, 1977), reproduced as Figure 2-3, does not indicate the presence of any wetlands or deepwater habitats on the ridgetop or slope within 500 feet of the property. Putnamville Reservoir is delineated as Lacustrine Limnetic Open Water (L1OW), with no indication of fringe wetlands along the northern shore abutting the ridge. The unnamed impoundment 1,000 feet north of the property is designated as Palustrine Open Water (POW), while the small wetland at the western end of this impoundment is delineated as a Palustrine Shrub/Scrub wetland (PSS). The perennial stream flowing into and out of the impoundment is designated as a Palustrine Forested wetland (PFO), as is the western section of Wenham Swamp to the northeast. No other wetlands or deepwater habitats are depicted in the vicinity of the property.

The USDA/SCS *Soil Survey of Essex County* (USDA/SCS, 1981 and 1984), reproduced as Figure 2-4, indicates that Udorthents, smoothed (UD) and Paxton fine sandy loam, 3 to 8 percent slopes are the predominant soil types on and in the immediate vicinity of the property. None of the soil types depicted on or within 500 feet of the property are considered poorly or very poorly drained hydric (wetland) soils (NTCHS, 1991). The nearest wetland soils are located approximately 1000 feet from the property boundaries. Soils within the wetland area at the western end of the impoundment (north of the site) are classified as Medisaprists, deep (MC). Soils along the unnamed stream upstream of the impoundment are designated as Whitman loam (Wg), while those in the stream basin downstream of the impoundment are classified as Saco Variant silt loam (Sa) until it reaches Wenham Swamp, which is classified as Medisaprists, deep (MC). Whitman, Medisaprist and Saco soil types are classified as hydric (wetland) soils (NTCHS, 1991).

According to the MNHESP *Massachusetts Atlas of Estimated Habitats of Rare Wetlands Wildlife* (MNHESP, 1993), reproduced as Figure 2-5, no state-listed rare wetlands wildlife species habitat or certified vernal pools are known to exist on or in the vicinity of the property. The nearest state-listed wetland species habitat is located approximately 12,000 feet east of the property, associated with Cedar Pond. In 1991, as part of the Defense

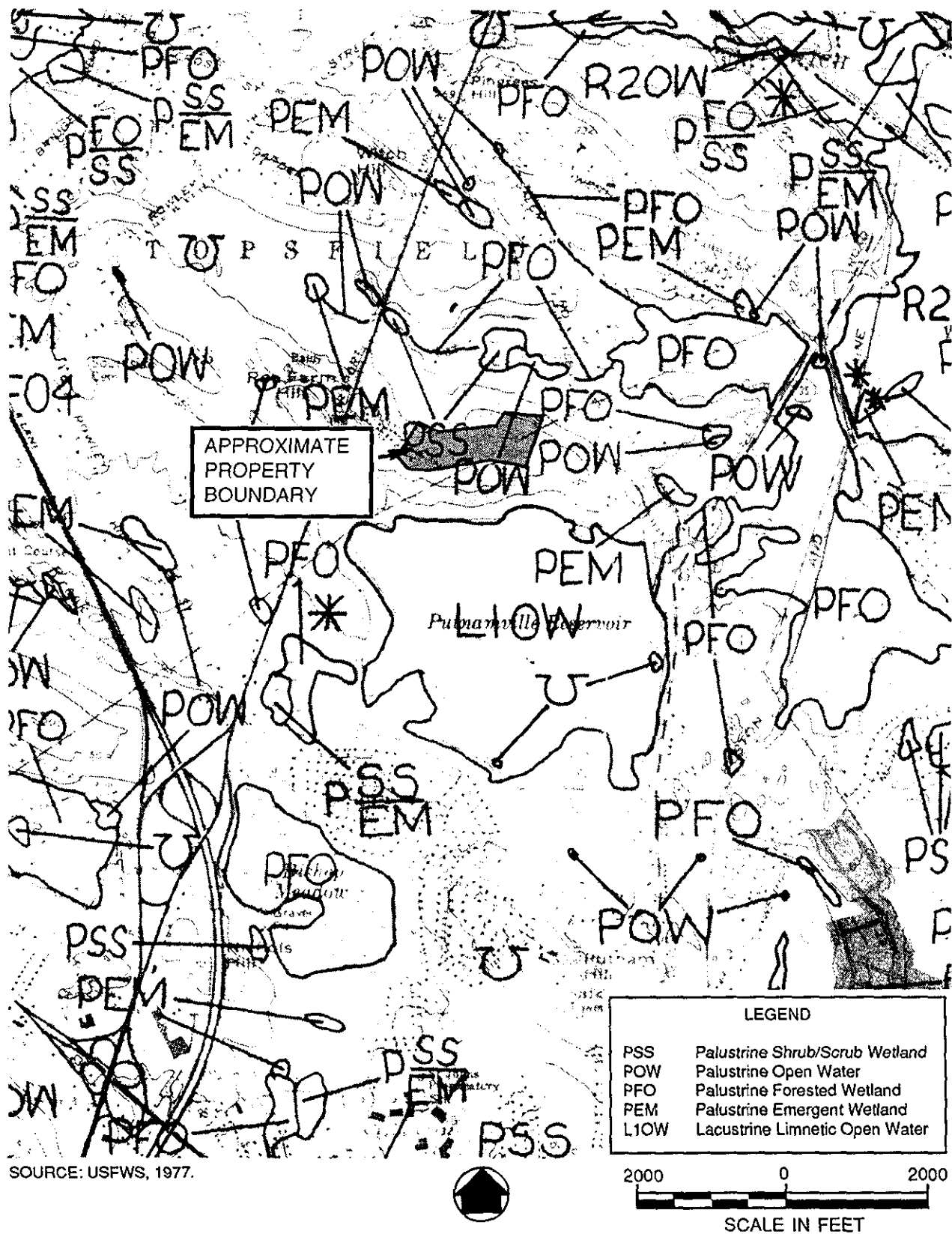


FIGURE 2-3. NATIONAL WETLANDS INVENTORY OF TOPSFIELD LAUNCH SITE BO-05

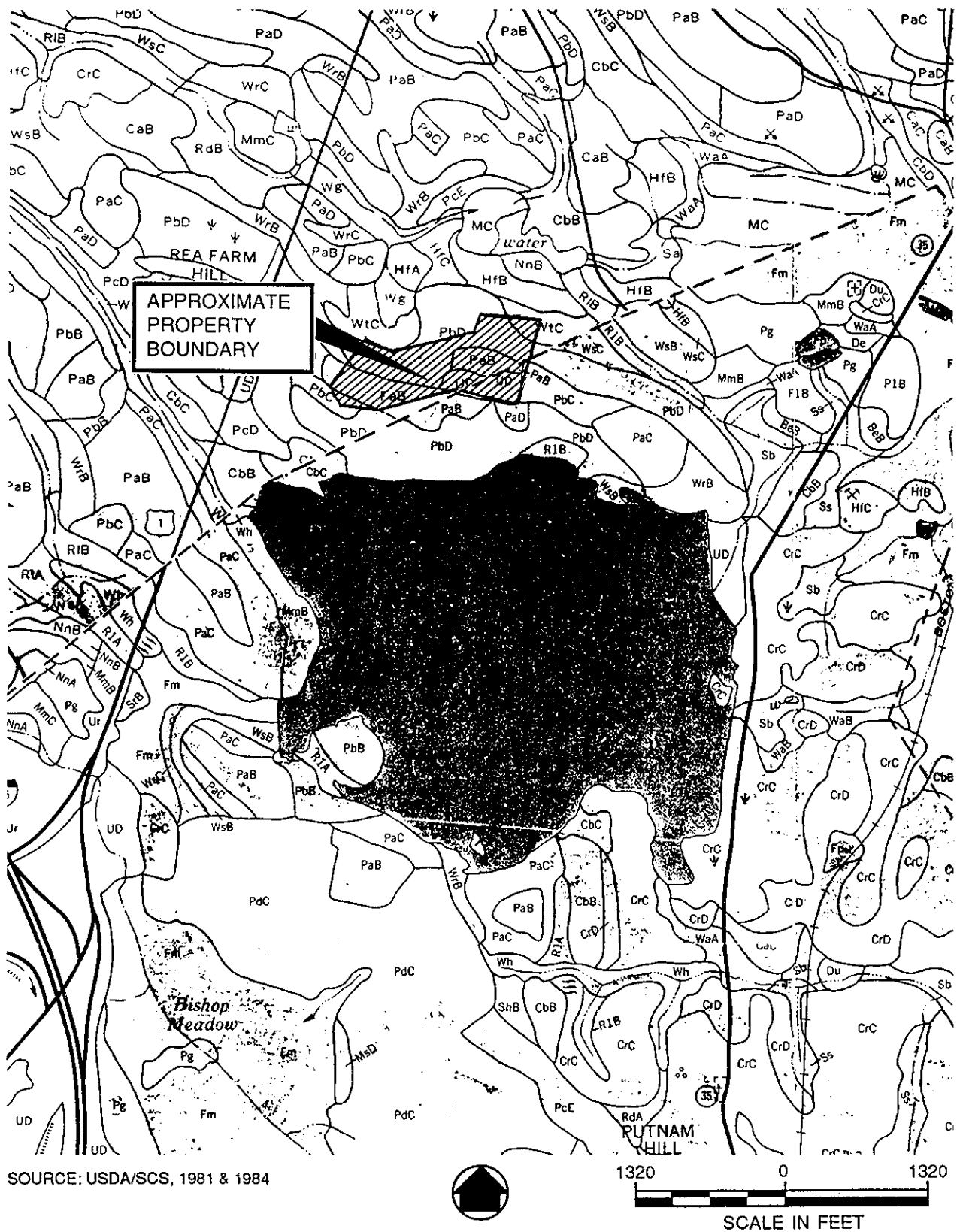


FIGURE 2-4. SOIL SURVEY OF TOPSFIELD LAUNCH SITE BO-05

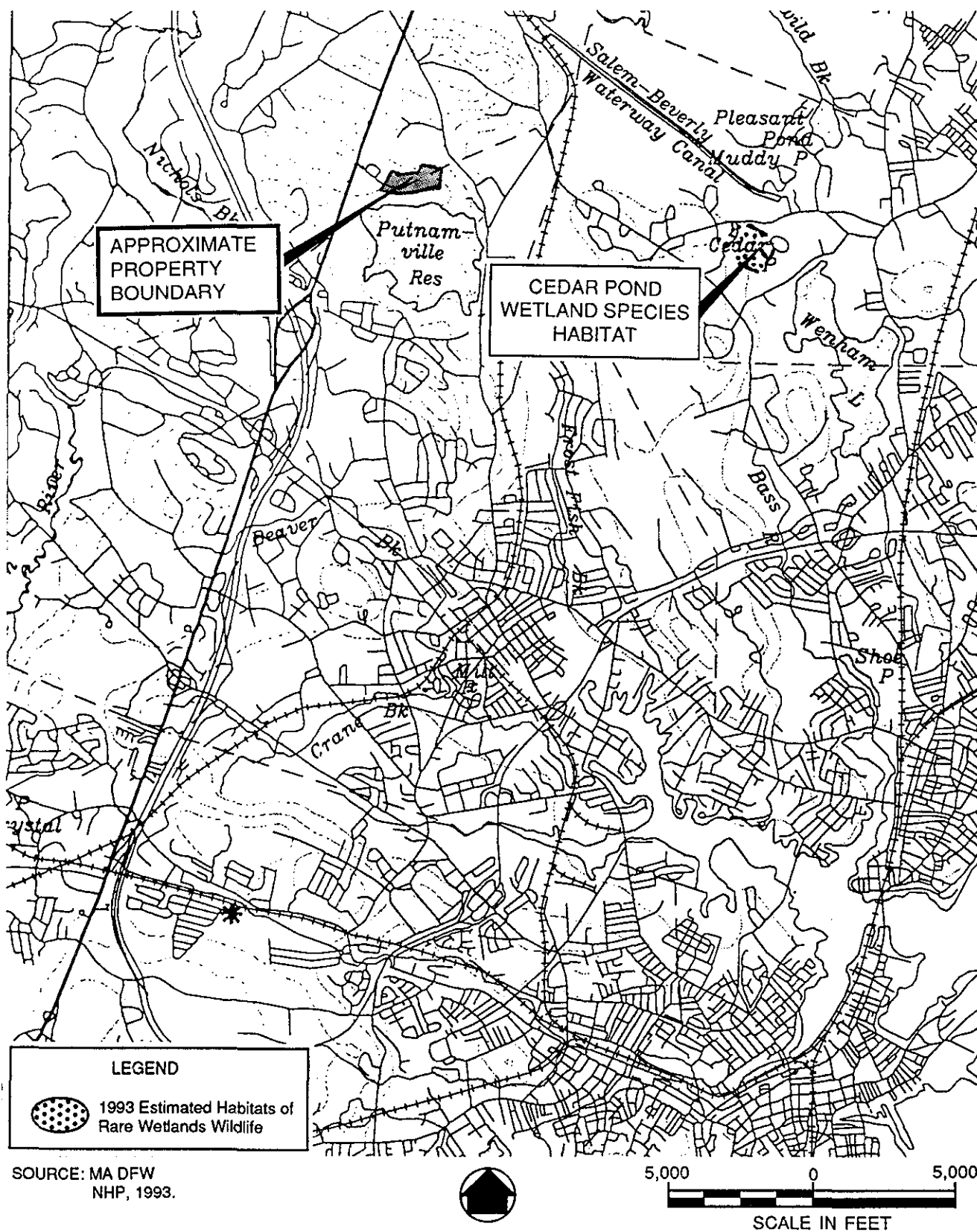


FIGURE 2-5. ESTIMATED HABITATS OF STATE-LISTED RARE WETLANDS WILDLIFE NEAR TOPSFIELD LAUNCH SITE BO-05

Environmental Restoration Program, USACOE corresponded with MNHESP and the U.S. Fish and Wildlife Service. The agencies determined there were no known federal or state-listed threatened or endangered species at the property at that time, with the exception of occasional, transient Bald Eagles (*Haliaeetus leucocephalus*) or Peregrine Falcons (*Falco peregrinus*). Correspondence from MNHESP received in 1994 reiterated that there may be transient occurrences of bald eagles and peregrine falcons within the vicinity of the property (MNHESP, 1994). The correspondence also reported the occurrence of Golden-winged Warbler (*Vermivora chrysoptera*) northwest and northeast of the project site. These areas are delineated in the MNHESP Massachusetts Natural Heritage Atlas, 1995-1996 Edition as high priority sites of rare species habitat. Both sites are upland sites that are not expected to be affected by site contamination. Copies of the natural resources correspondence were provided in the Phase I Report (M&E, 1996).

The FEMA *Flood Insurance Rate Maps* (FEMA, 1976 and 1977), reproduced as Figure 2-6, depict no flood hazard areas on or near the property. The site and the land within 500 feet of the property are not located within the 100-year floodplain (Zone A) of any water body.

The review of available resource maps determined that no water bodies, streams, wetlands or vernal pools are known to exist on or within 500 feet of the property. The resource maps depict Putnamville Reservoir approximately 750 feet to the south of the property, and wetland/open water complex approximately 1,000 feet to the north. Also, as described further in Section 3.3 (Site Hydrogeological Characteristics) there are no drinking water supplies consisting of Zone II areas, interim wellhead protection areas, Zone A areas, potentially productive aquifers, or private wells, nor are there any sole source aquifers, on or within 500 feet of the property.

2.3.2 Field Survey. A field survey of the property was conducted in April 1994 to verify the findings of the resource mapping review, to further characterize the ecological communities, and to look for evidence of impacts from contamination. The field investigation included a

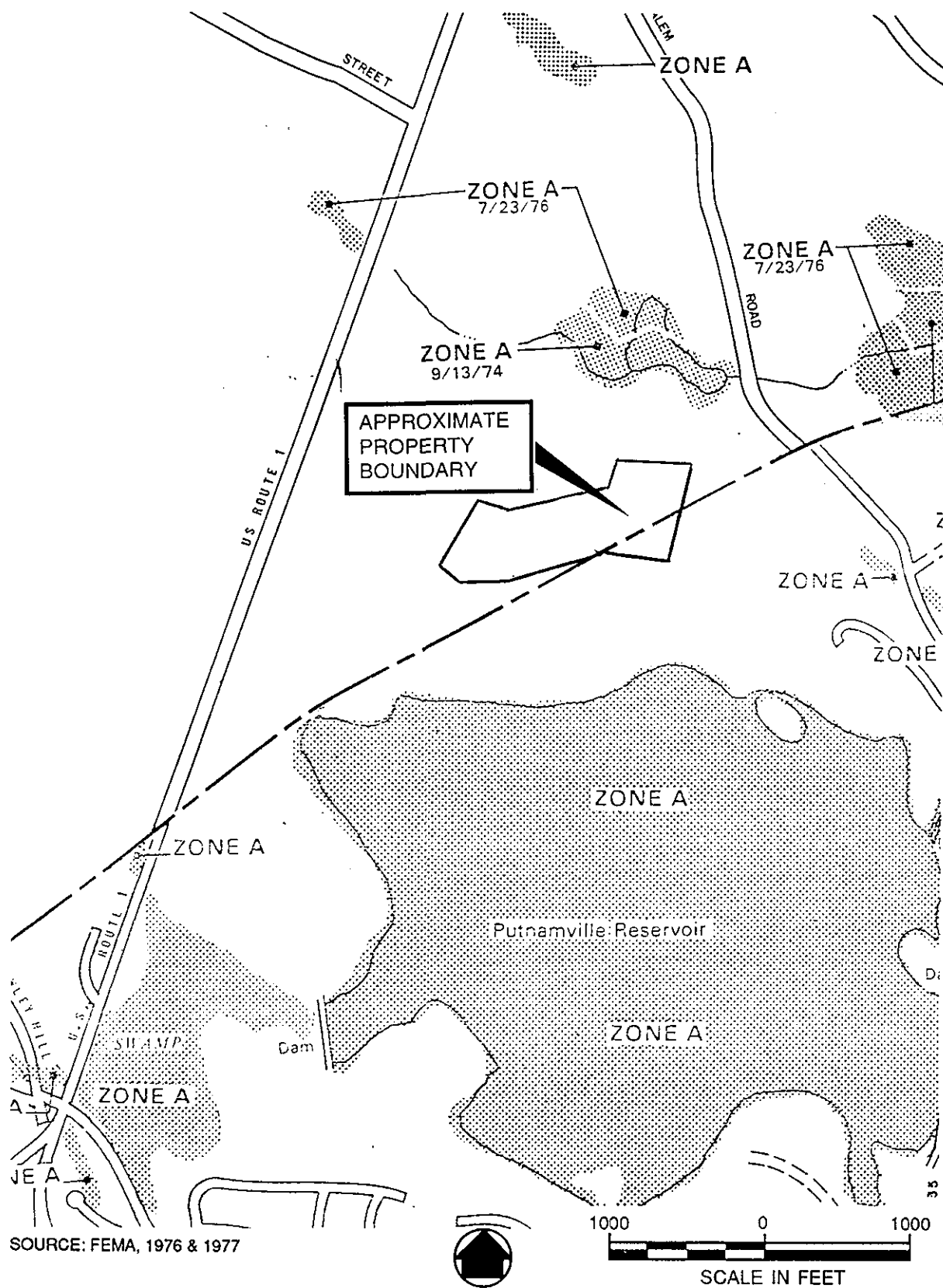


FIGURE 2-6. ZONE A (100-YEAR FLOODPLAIN) NEAR TOPSFIELD LAUNCH SITE BO-05

natural resources survey of the property and the adjacent lands. It was apparent that the majority of the property, including the disposal site area, was cleared of woody vegetation when the facility was in operation (1955-1977). Natural successional processes have since occurred, resulting in a complex of open meadow, scrub/shrub and young deciduous forest communities on the property.

The land in the western portion of the property and encompassing the disposal site, consists primarily of open meadows with areas of scrub/shrub vegetation. The open meadow habitat includes tall grasses and other herbaceous vegetation, including rye (*Elymus virginicus*), Queen Anne's lace (*Daucus carota*), milkweed (*Asclepias syriaca*), and common mullein (*Verbascum thapsus*). Scrub/shrub vegetation is prevalent along fences and in patches interspersed throughout the open areas and includes rose (*Rosa spp.*), black raspberry (*Rubus occidentalis*) and other thorned shrubs, vines (*Vitis spp.* and *Rhus radicans*) and other deciduous shrub species. An uninterrupted open meadow occupies the area from the missile service station (approximately the geographical center of the property) north to the chain-link fence, and east to the property boundary. Interspersed open meadow-scrub/shrub complex is also found on the property south from the access road to the chain-link fence.

A deciduous forest community occupies the northern portion of the property, from the chain-link fence to the property boundary. Dominant tree species are red maple (*Acer rubrum*) and American elm (*Ulmus americana*), with a moderate cover (40%) of deciduous understory growth. The majority of the trees in the northwestern corner of the property (downslope of the leaching field) are less than eight inches in diameter. The remaining forested area on the property (north of the chain-link fence) appears older, with larger trees (dominated by red maple with some white pine, *Pinus strobus*) and greater understory growth.

During the field survey, extensive wildlife presence was evident, through observation of both wildlife and their sign. Numerous birds including blue jay (*Cyanocitta cristata*), black-capped chickadee (*Parus atricapillus*) and mourning dove (*Zenaidura macroura*) were audible in the

shrub and thicket areas, particularly in the vicinity of the guard house and barracks. Gray squirrels (*Sciurus carolinensis*) were observed throughout the property. A red-tailed hawk (*Buteo jamaicensis*) was observed perched on utility poles and hunting throughout the open portions of the property. Visual signs (tracks, scat, etc.) of white-tailed deer (*Odocoileus virginianus*), eastern cottontail rabbit (*Sylvilagus floridanus*), and deer mouse (*Peromyscus maniculatus*) were evident, particularly in the tall grass of the open meadows. Based upon the presence of suitable habitat and known occurrences in the region, the property is also expected to be used by garter snake (*Thamnophis sirtalis sirtalis*), eastern American toad (*Bufo a. americanus*), eastern box turtle (*Terrapene c. carolina*), masked shrew (*Sorex cinereus*), shorttail shrew (*Blarina brevicauda*), star-nosed mole (*Condylura cristata*), eastern chipmunk (*Tamias striatus*), New England cottontail (*Sylvilagus transitionalis*), opossum (*Didelphis marsupialis*), striped skunk (*Mephitis mephitis*), raccoon (*Procyon lotor*), long-eared owl (*Asio otus*), crow (*Corvus brachyrhynchos*), barn swallow (*Hirundo rustica*), and finches and sparrows (Fringillidae), as well as numerous other species common to New England (Degraaf and Rudis, 1983).

No wetlands, vernal pools, streams or deepwater habitats were observed on the property. Standing water one to three inches deep covered the area from which the generator building had been removed, south of the missile assembly and test building. This area appeared to be seasonally saturated, but neither hydrophytic vegetation nor hydric soils are present. Therefore, this area does not constitute a wetland. This wet area drains through a culvert that runs under the access road and off-site to the south. Several other culverts under the access road also drain surface water runoff from the site downslope towards the south.

No sensitive natural resource areas were observed on the property during the field survey. Ecological communities on the property are typical of those observed in previously developed, abandoned areas: old field/open meadow habitat, scrub/shrub thickets, and deciduous forest. Due to the location of the property atop a ridge, the sloping topography and the presence of drainage culverts, no wetlands, streams, or deepwater habitats exist on the property.

The field survey included reconnaissance of adjacent lands within 500 feet of the property line to determine if there were any sensitive natural resource areas. The area west of the property is occupied by the NUVA shelter consisting of paved roads, houses, and small lawn areas. To the north, the topography slopes steeply away from the property, and the deciduous forest community described on the property occupies the entire area within 500 feet of the property. Beyond 500 feet north of the property, a series of streams, small ponds and palustrine scrub/shrub and emergent wetlands flows from west to east as indicated on the resource maps.

The mature deciduous forest extends to the east and south of the property. A residential development (Putnam's View) is located east of the site. A portion of the road for the development and two houses are located within 500 feet of the property boundaries, but this development, including the houses and portion of road closest to the property boundary, are outside the 500 foot radius from the disposal site.

A sloping meadow is located adjacent to the chain-link fence south of the barracks. Deciduous forest occupies the area south and east of this open meadow. A culvert runs under the access road at the southwest corner of the barracks and drains into a shallow grass-lined swale (dry at the time of the site visit) across the open meadow. The swale continues south into the forested area. In the forest between the open meadow and Putnamville Reservoir, an area of saturated soils and emergent wetland vegetation was observed (purple loosestrife, sphagnum moss, sensitive fern). This area is approximately 500 feet south of the property boundary, but is outside the 500 foot radius from the site boundary. The hydrology of this wetland is the result of both the surface water runoff in the swale and groundwater seepage from the face of the slope. The runoff flows south to the base of the slope, into a deciduous forested wetland (red maple swamp). There the surface water runoff from the property and the groundwater seepage joins a larger intermittent stream that originates to the northwest (near the intersection of Route 1 and the property access road) and flows into Putnamville Reservoir. The emergent wetland associated with the groundwater seep is the only wetland identified within 500 foot of the property boundary. The approximate location of this emergent wetland is shown on

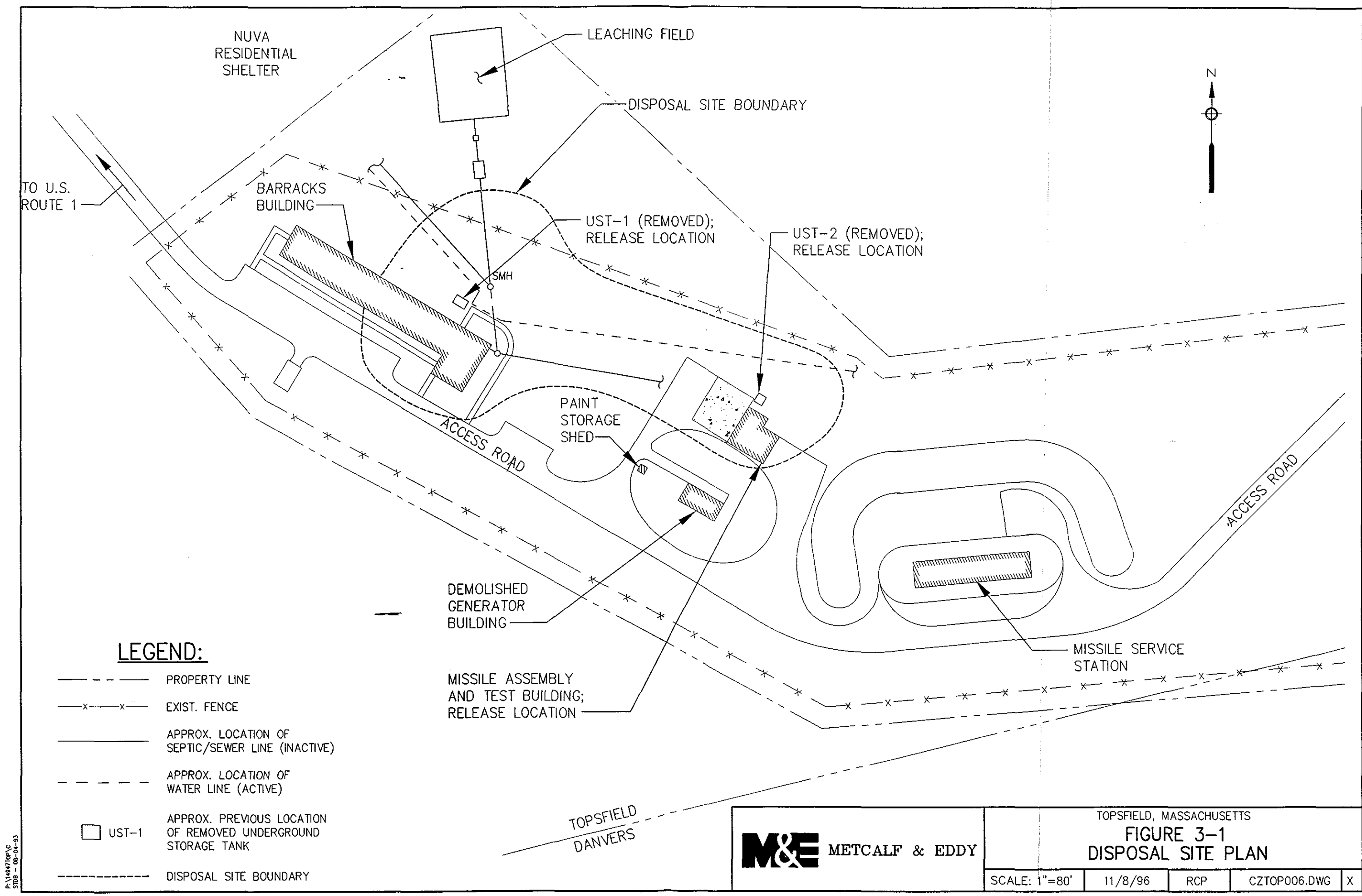
Figure 2-1. No wetlands, including the wetland described above, were identified within 500 feet of the disposal site boundary.

3.0 SITE-SPECIFIC BACKGROUND INFORMATION

3.1 Site-Specific Description

The entire property encompasses approximately 18.2 acres. However, the area defined as the disposal site and the focus of this report encompasses a significantly smaller, isolated area within the property boundaries. The disposal site is limited to the western portion of the property where two underground fuel oil storage tanks were determined to have leaked some of their contents (MADEP, 1991a and 1992), and low concentrations of chlorinated VOCs were detected in groundwater (M&E, 1996). Specifically, the disposal site is defined as a contiguous area encompassing the location of the three releases that have occurred at the property (i.e., the previous locations of UST-1 and UST-2 and the vicinity of the missile assembly and test building) as well as the areas that have been impacted by those releases. Figure 3-1 shows the boundary of the disposal site. As shown on Figure 3-1, the significant structures within or near the disposal site area are the barracks building, the missile assembly and test building, and underground utilities.

3.1.1 Barracks Building. The barracks building is a small, single-story, cement block structure. The building is abandoned and in disrepair, as well as open and easily accessible. There were active, overhead power lines running to the building, which were removed during the 1996 site investigation. In September 1991, a 2,000 gallon underground storage tank (UST-1) was removed from behind the building, in the approximate location shown on Figure 3-1. This tank was used for the storage of diesel fuel oil until approximately 1977, after which it was unused until it was removed (KELCO, 1992a; USACOE, 1994). At the time of tank removal, an unknown volume of fuel was observed in the tank and oil-stained subsurface soil was visible in the excavation (KELCO, 1991). The source of fuel oil contamination of subsurface soils in the vicinity of the barracks building is likely to have been caused by discharge from the UST prior to or during removal (KELCO, 1992b). A



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	TOPSFIELD, MASSACHUSETTS			
	FIGURE 3-1 DISPOSAL SITE PLAN			
SCALE: 1"=80'	11/8/96	RCP	CZTOP006.DWG	X

memorandum prepared by USACOE during tank removal states that the fill pipe of the tank appeared to have a loose fitting. Therefore, leakage from this tank may have occurred over a sustained period of time as the tank was filled (McDowell, 1991).

3.1.2 Missile Assembly and Test Building. The missile assembly and test building is a small, single-story, cement block structure. The building is abandoned and in disrepair, as well as open and easily accessible. In September 1991, a 500 gallon underground storage tank (UST-2) was removed from behind the building, in the approximate location shown on Figure 3-1 (KELCO, 1991). This tank was used for the storage of diesel fuel oil until approximately 1977, after which it was unused until it was removed (KELCO, 1992a; USACOE 1994). At the time of tank removal, an unknown volume of fuel was observed in the tank and fuel oil was detected in the subsurface soil in the excavation (KELCO, 1991). The source of fuel oil contamination of subsurface soils in the vicinity of the missile assembly and test building is likely to have been caused by discharge from the UST prior to or during removal (KELCO, 1992b). During investigations conducted in 1994 and 1996, chlorinated VOCs were detected in groundwater in the immediate vicinity of the missile assembly and test building. As described later in this report, the source of this contamination is believed to be unrelated to the fuel oil release, and is likely due to the historical use of various solvents, anti-corrosion products and paints at the missile assembly and test building.

3.1.3 Underground Utilities. An active public water supply line crosses the property, passing through the disposal site area in the immediate vicinities of the former locations of UST-1 and UST-2. This water line provides drinking water to the NUVA residential shelter located east of the property. During the excavation of UST-1 and UST-2, this line did not appear to coincide with the expected locations as shown on the as-built drawings. As a result, the water line was broken during the excavation of UST-2, and a 13-ft section was replaced. The original material of construction is a fragile, cement asbestos material; the section that was replaced is constructed of cast iron (KELCO, 1991).

The ownership of the water line is questionable. The Town of Danvers provides the water, although town representatives state that their ownership of the line ends at their pump station, located immediately northeast of the property boundary. The area of the property through which the line passes is in Topsfield, but town representatives state that they do not own the line because it is on private property and they do not provide the water. The property owner (Salem and Beverly Water Supply Board) has stated that an easement exists along the waterline. Therefore, since the government still owns the land associated with the NUVA residential shelter, it is anticipated that they also maintain the easement. Should NUVA purchase the property they are currently leasing, they would also be likely to obtain ownership of the easement, including the water line.

In addition to the water line, there are septic and sewer lines behind the missile assembly and test building and the barracks building. These lines are believed to be inactive, since they appear to have been in place solely for use by the two buildings during the active life of the facility. One line runs from the missile assembly and test building to the barracks building, and extends towards a septic tank and leach field located in the northwestern corner of the property. A second line diverges off of the first prior to the septic tank, and runs approximately parallel to the water line towards the NUVA property. This line is believed to go to an existing, active wastewater treatment plant located on the NUVA property, which is currently used by them for wastewater disposal.

The anticipated locations of the water, sewer, and septic lines are shown on Figure 3-1, based on the locations indicated on as-built drawings and in field notes from excavation activities, and as confirmed to the extent possible through field observations (i.e., the presence of manhole covers). The exact locations of these underground utilities, as well as the presence of other potential underground structures, have not been determined.

3.2 Property and Site History

3.2.1 Ownership and Property Use. The property was operated as a NIKE missile battery from 1955 to 1973 and as an Army Reserve Center from 1973 to 1977, and remained unused from 1977 until 1981 (USACOE, 1994). The property is currently owned by the towns of Salem and Beverly, and administered by the Salem and Beverly Water Supply Board. The towns acquired the property on September 28, 1981, from the United States Department of Health and Human Services. Although the towns currently own the property, the transfer of the property was encumbered by restrictions in the deed and an accompanying "Cooperative Agreement" executed at the time of transfer. The two most significant restrictions are reportedly the government's right to reclaim the property for need within 30 years, and the restriction that the property can be used only for watershed protection. In accordance with the Agreement, no use of the property or buildings has occurred since acquisition by the towns in 1981 (Knowlton, 1991).

Since the Department of Defense previously owned the property, USACOE volunteered to clean up the disposal site under the Defense Environmental Restoration Program. Therefore, USACOE has been identified as the responsible party under the MCP (MADEP, 1991a).

3.2.2 Release History. Three releases have been identified at the property. As defined previously, the area encompassing these releases comprises the disposal site. The first release was an unknown volume of fuel oil from UST-1, the 2,000 gallon tank that was previously located behind the barracks building. This release was identified during removal of UST-1 in 1991. The second release was an unknown volume of fuel oil from UST-2, the 500 gallon tank that was previously located behind the missile assembly and test building. This release was identified during removal of UST-2 in 1991. The third release, identified in 1994 during investigation activities, consists of chlorinated VOCs in groundwater in the vicinity of the missile assembly and test building. The source is likely historical, since operations at the

missile assembly and test building included the use of various solvents, anticorrosion products and paints. No current sources of chlorinated VOCs have been identified.

3.2.3 Regulatory History. On September 11, 1991, the MADEP Emergency Response Branch investigated reports concerning the releases of fuel oil discovered during the removal of UST-1 and UST-2. Pursuant to M.G.L. Chapter 21E and 310 CMR 40 (Case Number ERB-N91-1269) MADEP issued an NOR to USACOE, New England Division, who accepted responsibility for the releases (MADEP, 1991a). In conformance with the NOR, USACOE filed an incident report with the MADEP for the release on January 11, 1992.

In September 1992, the Emergency Response Branch concluded that no further emergency response actions were required at the site. However, they identified the need to evaluate further remedial measures in the locations of UST-1 and UST-2, and referred the case to the MADEP Site Management Branch as a Location to be Investigated (LTBI), pursuant to the old MCP 310 CMR 40.520(1) (Fagan, 1992). MADEP subsequently assigned the site a new case number, LTBI 3-4136 (MADEP, 1992).

On February 21, 1995, Metcalf & Eddy, contractor to USACOE, detected 1,1-dichloroethene, a chlorinated VOC, in the groundwater behind the missile assembly and test building at estimated concentrations exceeding the applicable MCP Reportable Concentration. USACOE notified MADEP of this release on June 20, 1995. On July 13, 1995, MADEP issued USACOE an NOR, assigning this release the Release Tracking Number (RTN) 3-12607. On June 20, 1996, USACOE submitted a Phase I Report and Tier II Classification to MADEP. The report and Tier Classification was completed for all three site releases, addressing LTBI 3-4136 and RTN 3-12607. The disposal site is currently tracked as RTN 3-4136.

No information is available on any other permits or regulatory activities associated with the historical use of the property.

3.3 Site Hydrogeological Characteristics

3.3.1 General Characteristics. The USGS Surficial Geology Map of the Salem Quadrangle indicates that surficial geology at the property consists of ground moraine comprised of poorly sorted deposits of sand, silt, clay and gravel (USGS, 1964). Deposits vary in composition from a loose sandy matrix to a dense matrix of silt and clay containing sand and gravel. Included in the glacial till are numerous boulders and small lenses of stratified sands and gravels. The ground moraine extends north of the property to the perennial stream which flows east to the Wenham Swamp and east to Locust Street. West of the property is a drumlin which forms Rea Farm Hill. The drumlin consists of an older till which underlies the ground moraine and trends northwest to southeast. Both units date to the Quarternary Period and were deposited during the Wisconsin glacialation of the Pleistocene. No bedrock outcrops are mapped on the property. Several boulders were found on the property during the April 1994 site visit, but no outcrops were observed.

The Bedrock Geology of the Salem Quadrangle indicates that the property is underlain by Precambrian interbedded biotite-microcline-oligoclase augen gneiss and plagioclase amphibolite (Toulmin, 1964). Structurally, the members of the Marlboro Formation lie within a southwest plunging syncline which is overturned to the northwest. Bedding planes in the vicinity of the property generally strike northeast and dip steeply to the northwest. No structural features are mapped within 500 feet of the property.

The earliest known subsurface investigation conducted in the vicinity of the property was a geophysical seismic study to determine the nature of soils and depth to bedrock in areas of proposed roadcuts along Route 1 between Danvers and Salisbury. As part of this study, seismic data was collected at Turnpike Hill, now called Rea Farm Hill, located approximately 1000 feet west of the property. In addition to conducting the seismic study, the geology within a one-half mile corridor along Route 1 was mapped. The study found Turnpike Hill to be comprised of compact till with depth to bedrock being at least 45 feet and in some areas at

least 170 feet (Eschman and Currier, 1948). A compilation of geophysical studies performed by Weston Geophysical Engineers, Inc. in the Salem Quadrangle determined that soils between Witch and Pingrees Hills, located approximately 3/4 mile north of the property, are comprised of compact soils with depths to bedrock ranging between 132 and 160 feet (Weston Geophysical Engineers, Inc., 1967). Records of bedrock wells drilled east of the property on Locust Street in Danvers (Route 35) and north of the property on Pingrees Hill indicate the bedrock surface is 99 and 80 feet below the ground surface at these two locations, respectively (Sammel and Baker, 1962).

The property is located within the Ipswich River Drainage Basin (Sammel et al., 1964). The access road and buildings are situated on relatively level ground which trends east to west. From the entrance to the property (west) to the rear of the property (east), the ground surface rises gradually with an elevation change of approximately 20 feet. The ground elevation drops off moderately for approximately 200 feet north and south of the access road before dropping off sharply on either side. Several shallow valleys on both sides of the access road channel runoff from the property. Surface runoff on the south side of the property flows to an unnamed intermittent stream which discharges to the Putnamville Reservoir. Runoff to the north flows to a perennial stream and its associated wetlands which discharge to Wenham Swamp.

According to the MADEP Bureau of Waste Site Cleanup (BWSC) Priority Resources Map, the property is not located within 500 feet of an Interim or MADEP Approved Wellhead Protection Area (IWPA or Zone II, respectively). Nor is the property within 500 feet of a municipal water supply or productive aquifer. The MADEP defines potentially productive aquifer as "... aquifers delineated by the U.S. Geological Survey (USGS) as a high or medium yield aquifer...". There are no such aquifers within 500 feet of the property. A sole source aquifer, which is defined by the EPA as being the sole or principal source of drinking water for an area, is not located within 500 feet of the property (Delaney and Maevisky, 1980).

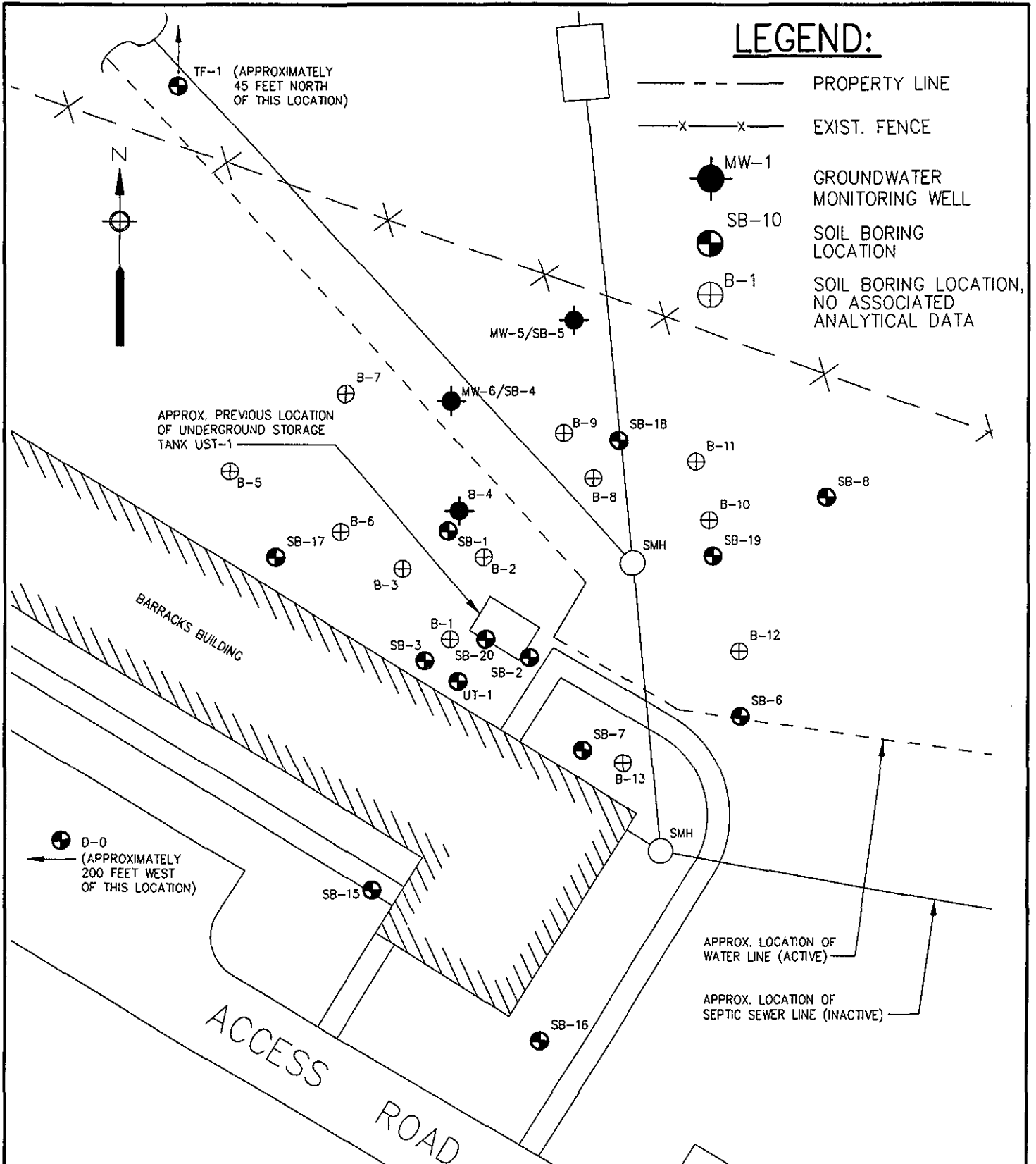
3.3.2 Soil Borings. Since 1987, a total of 43 soil borings relevant to the disposal site have been drilled at the property, twelve of which were completed as groundwater monitoring wells. These borings are described below, based on investigation dates. The locations of the borings are shown on Figures 3-2 through 3-4, as appropriate. Groundwater monitoring wells are further discussed in Section 3.3.3.

In 1987, eight soil borings were drilled, four of which were completed as groundwater monitoring wells. These borings were designated D-0, TF-1, UT-1, UT-3, and MW-1 through MW-4 (Donohue, 1987). In 1991, thirteen soil borings (B-1 through B-13) were drilled behind the barracks building; B-4 was completed as a groundwater monitoring well (KELCO, 1992a). Soils encountered in the borings from the 1987 and 1991 investigations consist of glacial tills comprised of a heterogeneous mixture of sands, silts, clays and subangular to subrounded gravels with occasional cobbles and boulders (Donohue, 1987; KELCO, 1992a). Boring logs associated with the 1987 and 1991 investigations were provided in the Phase I Report (M&E, 1996).

In 1994, eight soil borings (SB-1 through SB-8) were drilled behind the barracks building and six soil borings (SB-9 through SB-14) were drilled behind the missile assembly and test building. The depths of the boreholes ranged from 14 to 22 feet. Five of the borings (SB-5, SB-4, SB-10, SB-12, SB-13) were completed as groundwater monitoring wells (MW-5 through MW-9, respectively). Soils encountered in the borings from the 1994 investigations consisted of fill overlying stratified drift and glacial till. Fill materials consisted primarily of disturbed soils and ranged from two to nine feet in depth. Some plastic sheeting was encountered in SB-2, located behind the barracks building, between the ground surface and 2 feet. Disturbed soils were not encountered in all the borings. Stratified drift ranged from one to six feet in thickness and is comprised of silty sands and gravels. The glacial till, which was encountered at depths of two to nine feet below grade, consists of a dense, olive-gray matrix of silt, sand and gravel with occasional cobbles and boulders. Groundwater was encountered at depths

LEGEND:

- PROPERTY LINE
- x-x- EXIST. FENCE
- MW-1 GROUNDWATER MONITORING WELL
- ⊕ SB-10 SOIL BORING LOCATION
- ⊕ B-1 SOIL BORING LOCATION, NO ASSOCIATED ANALYTICAL DATA



TOPSFIELD, MASSACHUSETTS

FIGURE 3-2 BORING & MONITORING WELL LOCATIONS ASSOCIATED WITH UST-1

SCALE: 1"=30'

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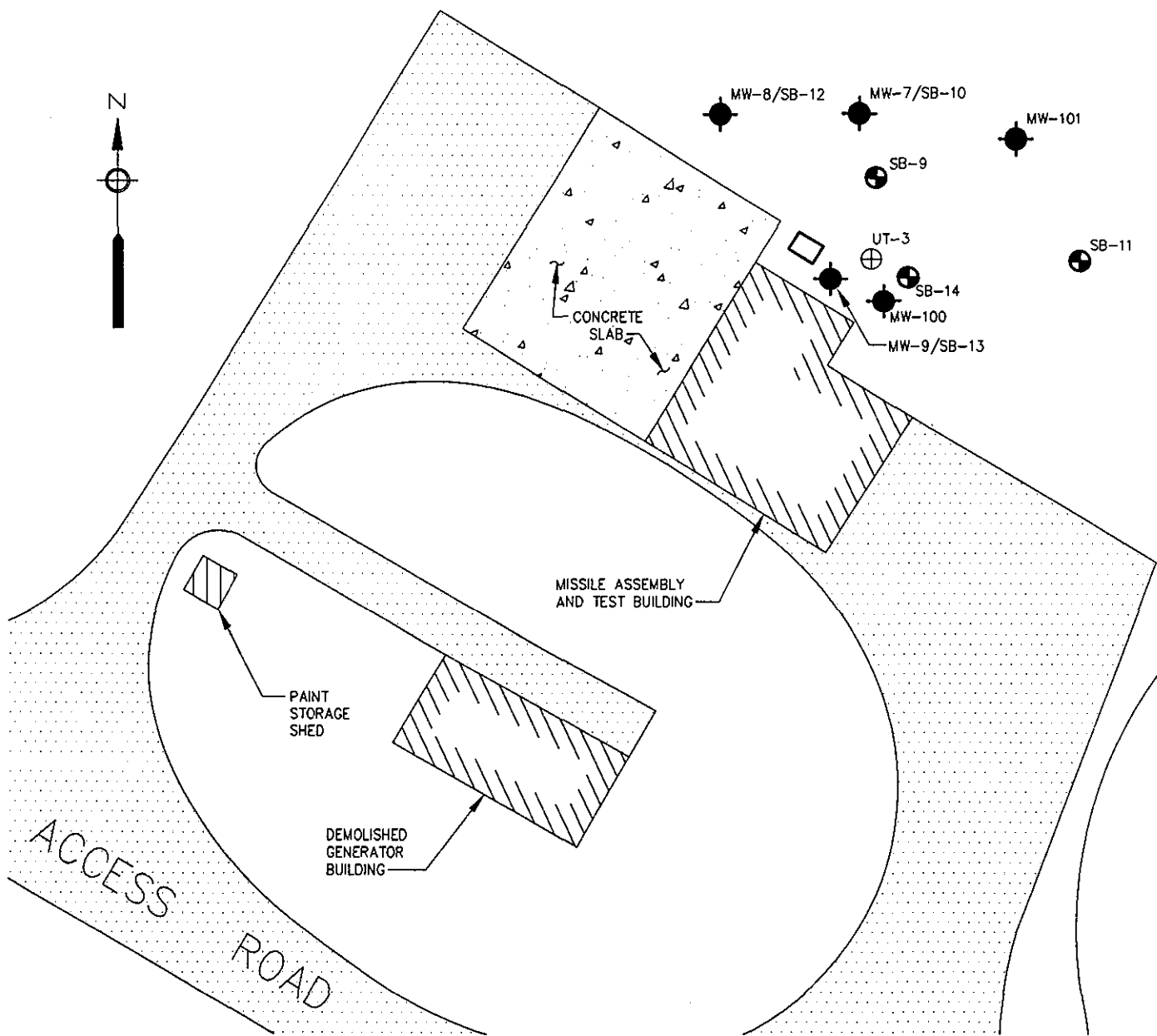
X

LEGEND:

- PROPERTY LINE
- x-x- EXIST. FENCE
- MW-1
● GROUNDWATER MONITORING WELL
- SB-10
⊙ SOILS BORING
- PREVIOUS LOCATION OF UST-2 (APPROX.)

NOTE:

SOIL BORING LOCATIONS SB-9 THROUGH SB-14 ARE BASED ON 1994 SURVEY BY GUERRIERE & HALNON, INC. SOIL BORING LOCATIONS MW-100 AND MW-101 BASED ON 1996 SURVEY BY M & E. SOIL BORING LOCATION UT-3 IS APPROXIMATE, BASED ON DONOHUE 1987.



TOPSFIELD, MASSACHUSETTS

FIGURE 3-3 BORING & MONITORING WELL LOCATIONS ASSOCIATED WITH UST-2

SCALE: 1"=30'

11/1/96

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X



METCALF & EDDY

ranging from four to ten feet below ground surface. Boring logs associated with the 1994 investigation were provided in the Phase I Report (M&E, 1996).

In April 1996, six soil borings were advanced behind the barracks building (SB-15 through SB-20). The depth of the boreholes ranged from 9 to 20 feet. Soils encountered in the borings are generally glacial till, consisting of very dense sand, silt and gravel with occasional cobbles and/or boulders. Copies of the boring logs are provided in Appendix A of this report.

In July and August 1996, two soil borings (MW-100 and MW-101) were drilled behind the missile assembly and test building. Groundwater monitoring wells were installed in both borings. The boring for MW-100 was advanced to a depth of 45 feet below ground surface. Soils encountered in the boring consist of approximately one foot of topsoil overlying glacial till. The glacial till is comprised of an overlying ablation till consisting of brown, fine to coarse sands and gravel with occasional cobbles or boulders. The ablation till extends to a depth of 19 feet below ground surface. Beneath the ablation till is a basal till; a gray, very dense matrix, primarily composed of silt with lesser amounts of sand and gravel and occasional cobble.

The boring for monitoring well MW-101 encountered approximately two feet of topsoil overlying 17 feet of ablation till and 11 feet of basal till. The materials in the tills were similar to that found in boring MW-100. The boring for MW-101 was advanced to 30 feet. Bedrock was not encountered in either boring. Copies of the boring logs are provided in Appendix A of this report.

3.3.3 Groundwater Monitoring Wells. Four monitoring wells (MW-1 through MW-4) were installed on the property in 1987; these wells are located outside the boundaries of the disposal site. Eight wells were subsequently installed within the site boundaries. Monitoring well B-4 was installed in 1991; monitoring wells MW-5 through MW-9 were installed in 1994; and monitoring wells MW-100 and MW-101 were installed in 1996. The locations of the twelve

wells installed on the property are shown on Figure 3-4. Monitoring well installation and development reports for MW-100 and MW-101 are included in Appendix A of this report; installation and development reports for the other wells were previously provided in the Phase I Report (M&E, 1996). Monitoring well MW-100 was completed as a deep well adjacent to monitoring well MW-9 to form a shallow/deep well cluster. This well cluster was used to determine if potential chlorinated VOCs had migrated vertically within the aquifer and to determine the vertical hydraulic gradient. Monitoring well MW-101 was installed north of the missile assembly and test building to determine whether potential chlorinated VOCs had migrated north of the building.

On October 17, 1996, groundwater levels were measured in all twelve monitoring wells. The data was used to update the site groundwater flow patterns presented in the Phase I Report, and to calculate the vertical hydraulic gradient in the aquifer in the vicinity of the missile assembly and test building, using monitoring wells MW-9/MW-100 as the shallow/deep well cluster. Groundwater elevations are shown in Table 3-1. Based on groundwater elevations measured for the shallow/deep well cluster, the vertical gradient in the immediate vicinity of the missile assembly and test building has an upward flow component of 0.0033 ft/ft.

Groundwater contours are shown on Figure 3-4. Groundwater flow for much of the property is south, towards the Putnamville Reservoir. These contours are very similar to those previously calculated for the property from elevations measured in 1995 (M&E, 1996), and are consistent with the presence of a groundwater divide at the center of the property in the immediate vicinity of the disposal site. Groundwater elevations and the corresponding contours for monitoring wells MW-7 and MW-101 suggest that groundwater north of the divide flows towards the intermittent stream and wetlands located north of the property.

3.3.4 Aquifer Testing. Slug tests were conducted in monitoring wells MW-1 through MW-4 in 1987, and in wells MW-5 through MW-9 in 1994. On September 9, 1996, slug testing was performed in wells MW-100 and MW-101. A slug test involves a rapid change in water level in the tested well. By measuring and recording the recovery or the rate of return to static

Table 3-1. Estimates Of Hydraulic Conductivity

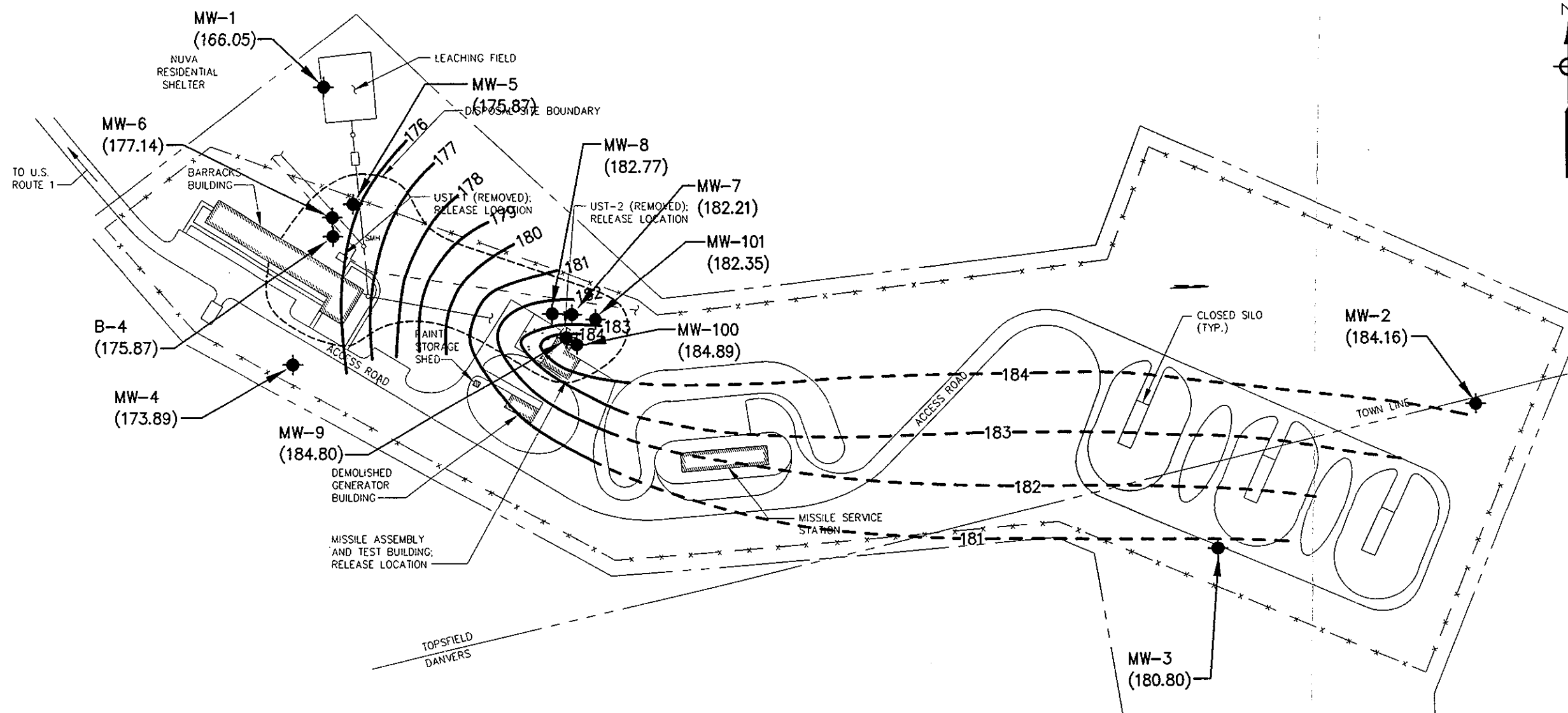
Monitoring Well ⁽¹⁾	Material Screened	Depth of Screen (ft. bls)	Top of PVC Elev. ⁽²⁾	Depth to Groundwater from Top of PVC(ft) ⁽³⁾	Groundwater Elevation ⁽³⁾	K ⁽⁴⁾ (ft/day)	K ⁽⁵⁾ (ft/day)	K ⁽⁶⁾ (ft/day)
MW-1	Glacial till	5-15	175.13	9.08	166.05	14.7		
MW-2	Glacial till	3-13	194.66	10.50	184.16	0.03		
MW-3	Glacial till	14-24	197.94	17.14	180.80	0.03		
MW-4	Unknown	13-23	182.02	8.13	173.89	0.02		
MW-5	Glacial till	5-15	183.80	7.93	175.87		0.12	
MW-6	Glacial till	4-14	184.55	7.41	177.14		0.06	
MW-7	Glacial till	7-17	193.56	11.35	182.21		0.07	0.03
MW-8	Glacial till	7-17	193.02	10.25	182.77		0.09	0.08
MW-9	Glacial till	7-17	193.70	8.90	184.80		0.10	0.08
MW-100	Glacial till	34-44	194.08	9.19	184.89		12.22	
MW-101	Glacial till	20-30	194.04	11.69	182.35		10.71	

ft. bls = feet below land surface

K = hydraulic conductivity

Notes:

1. Hydraulic conductivity was not measured for well B-4. Slug test data for MW-1 through MW-4 based on Donahue, 1987. Data and analysis for MW-5 through MW-9, MW-100, and MW-101 analyzed using Bouwer and Rice (1967) and Bouwer (1989). Data and analysis for MW-100 and MW-101 provided in Appendix B. Data and analysis for MW-5 through MW-9 was provided in the Phase I Report (M&E, 1996).
2. Datum for wells MW-1 through MW-9 based on survey by Guerriere & Halnon, Inc., December 1994; Datum for wells MW-100 and MW-101 based on survey by M&E, September 1996.
3. Groundwater levels measured on October 17, 1996.
4. Unknown how slug test data was collected.
5. Slug test data collected using pressure transducer and data logger.
6. Slug test data collected using water level indicator and stop watch.



LEGEND:

- 180 — GROUND WATER CONTOUR (DASHED WHERE INFERRED)
- MONITORING WELL WITH GROUND WATER ELEVATION (OCT. 17, 1996)
- - - - - PROPERTY LINE
- x-x-x- EXIST. FENCE

NOTE:

MONITORING LOCATIONS MW-1 THROUGH MW-9 BASED ON 1994 SURVEY BY GUERRIERE & HALNOR, INC. MONITORING LOCATIONS MW-100 AND MW-101 BASED ON 1996 SURVEY BY M & E.

M&E METCALF & EDDY

TOPSFIELD, MASSACHUSETTS
FIGURE 3-4
GROUND WATER CONTOURS

SCALE: 1"=150' 11/8/96 RCP CZTOP003.DWG X

conditions, the horizontal hydraulic conductivity (K) of the formation surrounding the well can be estimated. Estimates of the hydraulic conductivity at each well location are included in Table 3-1. The slug testing conducted in 1987 and 1994 was described in the Phase I Report (M&E, 1996). The recent slug testing is described below; the corresponding data and analysis are provided in Appendix B.

On September 9, 1996, slug testing was performed on monitoring wells MW-100 and MW-101 to determine aquifer characteristics. A three-foot bailer was placed into each well. After allowing the water levels in the wells to return to their initial static level, the bailers were removed. The resultant drawdown and recovery of the water level in each well was recorded with a transducer cable and data logger. The data was analyzed to calculate the hydraulic conductivity of the aquifer in the vicinity of the two wells.

Hydraulic conductivities for MW-100 and MW-101 were calculated to be 12.22 ft/day and 10.71 ft/day, respectively. These values are higher than values previously calculated for most of the monitoring wells on the property. Monitoring wells MW-100 and MW-101 are screened in sandy silt. The hydraulic conductivity value calculated for MW-1 was in the range of values calculated for MW-100 and MW-101. The boring log for MW-1 indicates a zone of silty sand with occasional gravel at 8 feet below ground surface which may account for the higher hydraulic conductivity. Monitoring wells MW-2 through MW-9, which have lower hydraulic conductivities (0.02 ft/day to 0.12 ft/day), are screened in silt. The hydraulic conductivity values calculated for all monitoring wells on the property fall within the range of values for glacial till.

4.0 DESCRIPTION OF SITE INVESTIGATIONS

Several investigations and remedial activities have been conducted at the property and disposal site. The investigations and activities which preceded the 1991 NOR focused on the entire property, while later investigations focused on the defined disposal site. A summary of the investigations, reports and remedial activities associated with the disposal site follows.

Results of the studies are presented in Section 5.0, Nature and Extent of Contamination.

Sampling locations are presented in Figures 3-2 and 3-3 in Section 3.0.

4.1 1987 Confirmation Study

On November 4, 1987, Donahue & Associates submitted the "Final Report for Confirmation Study at Former NIKE Missile Battery (BO-05) Danvers/Topsfield, Massachusetts" to the U.S. Army Corps of Engineers, Omaha District (Donahue, 1987). The report presents the results of a study which was conducted to make a preliminary determination of the presence or absence of chemical contamination on the property. This study preceded the identification of the leaking USTs, and, therefore, focused on the entire property and not just the defined disposal site.

Activities conducted during the confirmation study included collection of soil samples from 12 locations across the property; installation of four monitoring wells (MW-1 through MW-4) and collection of groundwater samples from those wells; collection of surface water from the three underground missile storage silos, and testing of a transformer which was located inside the former generator building. The soil and surface water samples were analyzed for VOCs and metals. Groundwater samples were filtered onsite and analyzed for dissolved metals. Separate aliquots of unfiltered sample were analyzed for VOCs and total petroleum hydrocarbons (TPH). The transformer was field screened for the presence of polychlorinated biphenyls (PCBs).

The confirmation study report concluded that the results of the groundwater, surface water and soil sampling were not indicative of the presence of significant areas of contamination at the property. The transformer was determined to contain PCBs. However, the transformer and the generator building in which it was located have since been demolished and removed from the property, and there has subsequently been a determination made that no residual contamination remains in that area (KELCO, 1991).

The results from the sampling and analysis of groundwater from all four wells, and the results from soil samples in the general vicinity of the two areas of contamination, are summarized in Section 5.0, Nature and Extent of Contamination. The sampling results of the surface water in the silos, the transformer, and the soils not in the vicinity of the disposal site are not relevant to the disposal site and, therefore, are not presented within this report.

4.2 1991 NIKE Silo and Tank Closure Project

A NIKE Silo and Tank Closure Project was performed in the fall of 1991 (KELCO, 1991). This project included the removal and disposal of three USTs, two above ground storage tanks, six waste drums, a transformer and a pole-mounted capacitor. In addition, the project included demolition of the generator building and closure of the three NIKE missile silos. Silo closure included dewatering the silos by pumping the water through a separator, holding tank, and carbon tank, and discharging to the ground. Influent and effluent samples were taken at the entrance to the separator and at the discharge of the carbon tank (KELCO, 1991).

Prior to initiating this project, USACOE performed limited environmental sampling and testing across the property. During the removal of UST-1 and UST-2, oil-stained subsurface soil was visible and volatile organics were detected at over 100 ppm using a field operated HNu photoionization detector (PID) (KELCO, 1991). Upon completion of the project, various analytical samples were collected and tested to confirm that all potentially contaminated material was removed and disposed of according to Federal, State and local regulations.

Testing of the soil excavated during the removal of UST-1 showed high levels of TPH and VOCs. Testing of the soils within the excavation pit of UST-2 showed high levels of TPH. With the exception of these two areas, other testing conducted at the time confirmed that there was no other residual contamination on the property (KELCO, 1991).

During the closure project, attempts were made to excavate the contaminated soil from the vicinity of both UST-1 and UST-2. However, removal was not completed because of uncertainty regarding the exact location of the water line, and limitations of the excavation equipment available (KELCO, 1991). Approximately 60 cubic yards of contaminated soil were excavated in the vicinity of UST-1, and approximately 35 cubic yards were excavated in the vicinity of UST-2. All of this excavated soil was removed from the site and disposed of at a recycling facility (KELCO, 1992b). Field notes indicated that the excavation at UST-2 was lined with poly-sheeting and backfilled with clean fill (KELCO, 1991). Information on how the excavation at UST-1 was filled is not available.

4.3 1991 Soil Boring Program at UST-1

As a result of the visible staining that was observed in subsurface soils during the removal of UST-1, a soil boring program was performed in November/December 1991 behind the barracks building to evaluate the extent of fuel oil contamination in that vicinity (KELCO, 1992a). Soil samples were taken from thirteen soil borings (B-1 through B-13) at three depths (5, 10, and 15 ft) in the area of former UST-1. The soils were screened onsite for VOCs using a PID, and the results were used to interpolate a minimum extent of contamination. The contamination was determined to have spread at least 45 ft radially from the previous location of UST-1, including under the barracks building. A groundwater monitoring well (B-4) was also installed in this vicinity, and one water sample and one soil sample (10-foot depth) were analyzed. The results of the laboratory analyses from B-4 are presented in Section 5.0.

4.4 1992 Excavation at UST-2

On May 11, 1992 a final attempt was made to remove the contaminated soil from the vicinity of UST-2. Approximately 38 cubic yards of additional soil was excavated, however, confirmatory sampling indicated the presence of limited areas of residual TPH contamination. The excavated soil was transported to an off-site recycling facility (KELCO, 1992c).

4.5 1994 Site Walkover

In April 1994, Metcalf & Eddy performed a walkover of the property. During the walkover, there was no visual or olfactory evidence of contamination at the property, including within the disposal site area (e.g., no stained soils, distressed vegetation or odors.) A slight sheen was observed on a small area of standing water (no greater than three square feet) in an isolated area of the property where the generator building was demolished; this area is outside the disposal site boundary. It is possible that this sheen was due to runoff from the access road or to natural sources such as microbial degradation of organic material, because there were no other sheens or visibly stained soils in the area, and this area was determined to have no significant residual contamination at the completion of the 1991 NIKE Silo and Tank Closure Project (KELCO, 1991). No sampling and analysis of any media (except ambient air monitoring for health and safety purposes) was conducted during the walkover. A memorandum describing the walkover was included in the Phase I Report (M&E, 1996).

4.6 1994 Site Investigation Study

In November and December, 1994, Metcalf & Eddy conducted investigations to determine the nature and extent of residual contamination associated with the release of fuel oil from UST-1 and UST-2. Work activities included: installing and sampling fourteen soil borings; installing, developing, and sampling five new monitoring wells; sampling three existing monitoring wells; conducting in-situ permeability tests on each of the newly-installed monitoring wells;

and conducting a survey of all sampling locations and other property features. Groundwater and soil samples were submitted to a laboratory for analysis for TPH, selected VOCs, and selected semivolatile organic compounds (SVOCs), as recommended by MADEP for the investigation of #2 fuel oil contamination (MADEP, 1991b). In addition, groundwater samples from all monitoring wells in the vicinity of UST-1 (MW-1, B-4, MW-5, MW-6) and the background monitoring well (MW-2) were analyzed for lead, because of the unconfirmed identification of lead in groundwater collected from this area during previous investigations.

4.7 1996 Site Investigation at UST-1

In April 1996, Metcalf & Eddy installed six soil borings in the vicinity of the barracks building. Boring locations were selected to further define the areal limits of the soil contamination resulting from the release at UST-1, and to obtain results from the area with the most elevated levels of contamination, the former location of UST-1, for use in risk assessment. Based on field screening results, the two most contaminated soil samples were selected from each boring and submitted to a laboratory for analysis for VOCs, SVOCs, volatile petroleum hydrocarbons (VPH), and extractable petroleum hydrocarbons (EPH). Boring locations were surveyed.

4.8 1996 Site Investigation for Chlorinated VOCs

From May 1996 through August 1996, Metcalf & Eddy conducted investigations to determine the source, nature, and extent of the chlorinated VOC contamination initially detected in groundwater during the 1994 investigation. Work activities consisted of the following: conducting a soil vapor survey in an attempt to locate a possible source; installing and sampling two soil borings; developing the two soil borings into monitoring wells; conducting in-situ permeability testing and surveying of the newly installed wells; and sampling groundwater from all the wells on the property. Groundwater and soil samples were analyzed for VOCs. The soil vapor survey was conducted using a field gas chromatograph (GC) to

analyze for selected chlorinated VOCs. The GC was also used to select soil samples from each boring for laboratory analysis. The results of the soil and groundwater analyses are presented and discussed in Section 5.0.

During the 1996 investigations, two soil samples, one each from boring MW-100 and boring MW-101, were collected and submitted to a laboratory for sieve analysis. The samples were collected from depths that corresponded with the anticipated center point of the monitoring well screen. The soil sample from boring MW-100 was collected from a depth of 42-44 feet. The soil sample from boring MW-101 was collected from a depth of 26-28 feet. The results of the sieve analysis are included in Appendix A. Both soil samples are described as a sandy silt. This is in agreement with the soil descriptions logged in the field for those depths.

5.0 NATURE AND EXTENT OF CONTAMINATION

Soil contamination at the disposal site is limited to two isolated areas: behind the barracks building, in the general vicinity of the previous location of UST-1; and behind the missile assembly and test building, in the general vicinity of the previous location of UST-2.

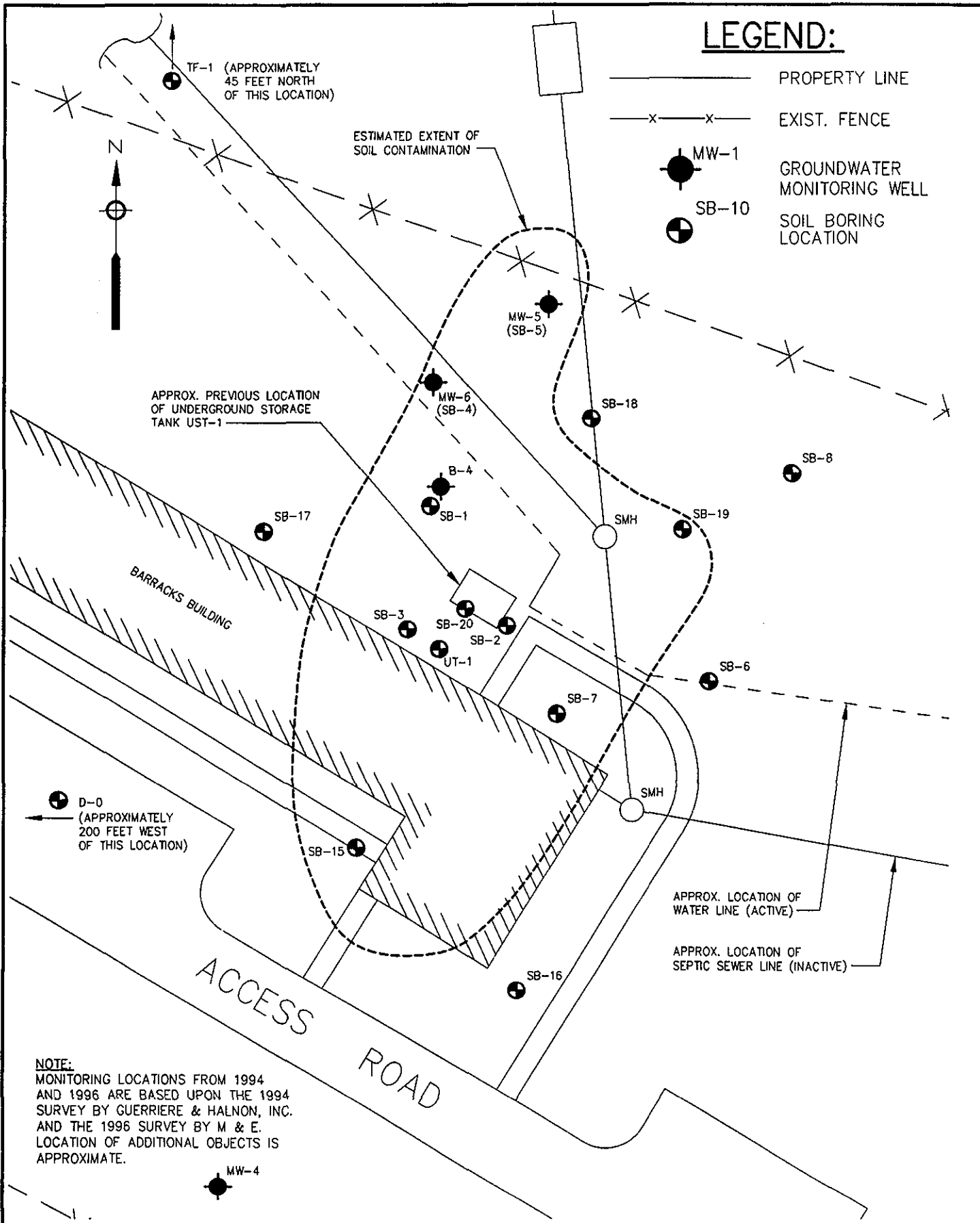
Groundwater contamination at the disposal site is limited to chlorinated VOCs in the vicinity of well MW-9, behind the missile assembly and test building. Sections 5.1 and 5.2 summarize the soil and groundwater analytical results associated with the two areas of contamination.

Analytical results are presented chronologically, including results from the initial site investigation in 1987 through the most recent site investigation in 1996. Although chlorinated VOC contamination in groundwater is not believed to be associated with the fuel oil releases from the USTs, analytical results associated with the chlorinated VOC release are presented along with those concerning the fuel oil releases since all three releases are part of the same disposal site. Where appropriate, soil analytical results are compared to MCP Method 1 S-1/GW-3 standards and groundwater analytical results are compared to MCP Method 1 GW-3 standards, to provide an indication of the level of contamination at the site. As described in Section 7.0, risks have been quantitatively estimated using MCP Method 3.

5.1 Summary of Analytical Results at UST-1

The results of sampling and analyses conducted in the vicinity of UST-1 are described below. Monitoring locations are shown on Figure 5-1. Monitoring locations which represent soil that has been removed from the site are not presented since they are no longer representative of site conditions. Soil analytical data is summarized in Table 5-1; groundwater analytical data is summarized in Table 5-2. Both of these tables are located at the end of Section 5.0.

5.1.1 Analyses from 1987 Confirmation Study. During the 1987 Confirmation Study performed by Donahue & Associates, samples collected in the vicinity of or relevant to UST-1



TOPSFIELD, MASSACHUSETTS

FIGURE 5-1 MONITORING LOCATIONS AND ESTIMATED EXTENT OF SOIL CONTAMINATION ASSOCIATED WITH UST-1

SCALE: 1"=30'

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included five soil samples and four groundwater samples. All samples were analyzed for VOCs, TPH, and metals. Sample depths were selected for VOC analyses based on field screening with a PID. Analytical results are summarized in Tables 5-1 and 5-2 and are described below.

5.1.1.1 Soils. Applicable soil samples are D-0, UT-1, MW-1, MW-4, and TF-1. These samples were collected from the locations shown on Figure 5-1, and as described below:

- D-0 was taken from a wooded area south of the property entrance, and is considered to be a background sample. The sample was analyzed for metals only.
- UT-1 was taken in close proximity to UST-1 prior to tank removal. Analyses for metals and TPH were based on a composite sample from depths of 2 feet and approximately 7 feet (estimated to be near the bottom of the tank). Analyses for VOCs were taken from a depth of approximately 5-7 feet. Due to the proximity of UT-1 to the building, this sample is believed to be representative of existing subsurface soil (i.e., beyond the extent of the previous excavation).
- Soil sample MW-1 was taken during the installation of monitoring well MW-1. Analyses for metals and TPH were based on a composite sample from depths of 0-2, 3-5, and 13-15 feet. Analyses for VOCs were taken from a depth of 3-5 feet.
- Soil sample MW-4 and a duplicate MW-4D were taken during the installation of groundwater monitoring well MW-4. Analyses for metals and TPH were based on a composite sample taken from depths of 0-2, 3-5, and 13-15 feet. Analyses for VOCs were taken from a depth of 13-15 feet.
- TF-1 and a duplicate TF-1D were taken from the tile field (leaching field) north of the barracks building. The purpose of this sample was to determine if chemical contamination was present as a result of waste disposal into the septic system. Analyses for metals and TPH were based on a composite sample from depths of 0-2 feet and 3-5 feet below the ground surface. Analyses for VOCs were taken from a depth of 0-2 feet.

No VOCs were detected in any of the soil samples, with the exception of acetone in soil sample MW-1. TPH was detected in all of the samples, with the highest concentration measured at UT-1. All TPH concentrations are below the Method 1 S-1/GW-3 Standard of

800 mg/Kg. Various concentrations of metals were detected in the soil samples. The results summarized in Table 5-1 indicate that the metals detected in various locations at times exceeded the concentrations from the background location (D-0). However, none of the results exceed the Method 1 S-1/GW-3 Standards.

5.1.1.2 Groundwater. Groundwater samples MW-1, MW-1D, MW-2, MW-3 and MW-4 were taken at each of the respective wells, following completion of well installation and development. The location of MW-4 is shown on Figure 5-1. Wells MW-1, MW-2 and MW-3 are shown on Figure 3-4, because they are not located in the immediate vicinity of the barracks building. VOCs were not detected in any of the groundwater samples. TPH was detected in two of the five samples (MW-1 and MW-3), but at concentrations significantly below the Method 1 GW-3 Standard of 20,000 $\mu\text{g/L}$. Separate phase fuel was not noted during groundwater sampling. Various metals were detected in the groundwater samples, generally at concentrations below the Method 1 GW-3 Standards. Lead and silver concentrations in MW-1 exceeded the Method 1 GW-3 Standards, however, these same parameters were non-detect in MW-1D, the duplicate for MW-1. Therefore, the presence of lead and silver in groundwater at well MW-1 was unconfirmed.

5.1.2 Analyses from 1991 Soil Boring Program. During the 1991 Soil Boring Program at UST-1, thirteen borings (B-1 through B-13) were advanced behind the barracks building. The soils from the borings were analyzed in the field using a PID to conduct a headspace analysis. This field screening was conducted at depths of 5, 10 and 15 feet. In general, contamination was typically not detected at the five foot depths. The greatest PID headspace readings were detected in the 10-15 foot depth range, with a maximum observed concentration of 154 ppm at a depth of 15 feet at boring location B-2. The only soil sample collected for laboratory analysis was at boring location B-4, from a depth of 10 feet. This sample was analyzed for TPH; the results showed a concentration of 450 mg/Kg, which is below the Method 1 S-1/GW-3 Standard of 800 mg/Kg. The location of B-4 is shown on Figure 5-1. Since

laboratory analyses were not conducted on samples from the other borings, the locations are not shown on Figure 5-1; these locations are shown on Figure 3-2.

During the soil boring program, a groundwater monitoring well was installed in the boring designated B-4, and a groundwater sample was collected for laboratory analysis of TPH. In the report that was prepared for the soil boring program, the well and its associated sample were designated MW-1 (KELCO, 1992a). Because a well installed in 1987 already has that designation, this newer well has been redesignated B-4 in this report, to avoid confusion. B-4 is the boring designation from which the well was developed. The results of the TPH analysis of groundwater sample B-4 (91,000 $\mu\text{g/L}$) exceeds the Method 1 GW-3 Standard of 20,000 $\mu\text{g/L}$. Separate phase fuel was not noted during the groundwater sampling.

5.1.3 Analyses from 1994 Site Investigation. During the 1994 investigation, samples collected in the vicinity of or relevant to UST-1 consisted of two soil samples from each of eight boring locations (SB-1 through SB-8), and five groundwater samples (MW-1, MW-2, MW-5, MW-6, B-4). The locations of these samples are shown on Figure 5-1, with the exception of MW-2 which is shown on Figure 3-4. The results are summarized in Tables 5-1 and 5-2 and are described below.

5.1.3.1 Soils. Two soil samples were collected from each of eight soil borings installed in the vicinity of UST-1. Soil samples were analyzed for a selected list of VOCs (benzene, toluene, ethylbenzene and total xylenes, otherwise known as BTEX) by SW-846 Method 8020, a selected list of SVOCs (naphthalene, 2-methylnaphthalene and phenanthrene) by SW-846 Method 8270, and TPH by SW-846 Method 418.1. These parameters are suggested by MADEP policy #WSC-401-91 for a release of #2 fuel oil (MADEP, 1991b). Depths selected for VOC analyses were based on field screening results (i.e., depths with highest headspace readings). Whenever possible, samples for SVOC and TPH analyses were taken from the same depth interval as the samples for VOC analyses. However, in several instances, additional sample volume was required for the SVOC and TPH analyses. In these cases,

samples collected from adjacent depths were composited with the sample collected from the depth initially selected for VOC analysis. The soil samples which were collected are as follows:

- SB-1 was placed near monitoring well B-4 in a previously indicated area of relatively high contamination. Soil samples selected for all analyses were from 6-8 and 10-12 feet below the surface.
- SB-2 was placed in the approximate location of the excavated tank. Soil samples selected for VOC analysis were from 6-8 and 10-12 feet below the surface. The sample depths for SVOC and TPH analyses were 2-8 and 10-12 feet.
- SB-3 was placed along the building foundation, a suspected preferential pathway, within the area previously determined to be contaminated. Soil samples selected for VOC analysis were from 4-6 and 10-12 feet below the surface. The sample depths for SVOC and TPH analyses were 4-8 and 10-12 feet.
- SB-4 was installed along the underground water/sewer lines, a suspected preferential pathway, downgradient of apparent areas of relatively high contamination. Soil samples selected for VOC analysis were from 8-10 and 10-12 feet below the surface. The sample depths for SVOC and TPH analyses were 6-10 and 10-14 feet.
- SB-5 was installed along the septic line to the leach field, a preferential pathway downgradient of the spill area. Soil samples selected for VOC analysis were from 8-10 and 12-14 feet below the surface. The sample depths for SVOC and TPH analyses were 2-10 and 10-16 feet. A field duplicate sample was also collected from both depths at this location.
- SB-6 was installed along the waterline upgradient (east) of the tank area to confirm the eastern limit of contamination. As there were no VOCs detected during headspace screening, samples were selected from depths 4-5.8 and 6-8 feet, estimated at that time to be in the vicinity of the water table. Sample depths for TPH and SVOC were 4-8 and 15-17 feet.
- SB-7 was installed along the building foundation, a suspected preferential pathway, within the area previously determined to be contaminated. Soil samples selected for all analyses were from 8-10 and 15-17 feet below the surface.

- SB-8 was installed upgradient of the tank area, to confirm the inferred limit of contamination. Soil samples selected for all analyses were from 2-4 and 20-22 feet below the surface.

During the advancement of borings and the collection of soil samples, staining and a strong petroleum odor were apparent at boring locations SB-1, SB-2, SB-3 and SB-7. VOCs were detected in only one soil sample, SB-3, from a depth of 10-12 feet. SVOCs were detected in four samples, collected from SB-1, SB-2, SB-3, and SB-7. All VOC and SVOC concentrations were below the Method 1 SW-1/GW-3 standards. TPH was detected in all soil samples except SB-1 (6-8 feet). Although the non-detect result for SB-1 was confirmed with the laboratory, the headspace screening result (146 ppm) and visual and olfactory observations suggest that some degree of contamination is present at that depth. TPH was most elevated in the sample from SB-2 (3,880 mg/Kg), which was the only concentration exceeding the TPH Method 1 S-1/GW-3 Standard of 800 mg/Kg.

5.1.3.2 Groundwater. Groundwater monitoring wells MW-5 and MW-6 were installed in soil borings SB-5 and SB-4, respectively. Groundwater samples MW-1, MW-2, B-4, MW-5, and MW-6 were collected from each of the respective wells. A field duplicate was collected for MW-1, and was designated MW-10 for purpose of submitting a blind duplicate to the laboratory. Groundwater samples were analyzed for a selected list of VOCs (BTEX), a selected list of SVOCs (naphthalene, 2-methylnaphthalene, and phenanthrene), and TPH, as suggested by MADEP policy #WSC-401-91 for a release of #2 fuel oil (MADEP, 1991b). Groundwater samples were also analyzed for lead, because of the unconfirmed elevated concentration of dissolved lead in well MW-4 in 1987.

No detectable concentrations for BTEX, SVOCs, or TPH were reported for the groundwater samples. Lead was detected in the groundwater sample from only B-4, but at a concentration below the Method 1 GW-3 standard of 30 $\mu\text{g/L}$. Because well B-4 was in poor condition, groundwater collected from this well was turbid despite the use of low-flow methods for

sample collection. Since lead was not detected in MW-4, the unconfirmed result from 1987 was determined to be not valid.

Trace levels of a few chlorinated VOCs were reported in some of the groundwater samples collected in the vicinity of UST-1. However, these compounds were not target compounds and all quality control requirements for their analysis were not conducted. Further, although the data was not validated, the associated trip blank and equipment blank for the groundwater samples in the vicinity of UST-1 were noted to contain similar concentrations of many of the same compounds. Since the validity of this data cannot be ascertained, it is not suitable for use in evaluating the presence or absence of chlorinated VOCs in the vicinity of UST-1.

5.1.4 Analyses from the 1996 Site Investigation

During the 1996 investigation, two soil samples were collected from each of six soil borings (SB-15 through SB-20) placed in the vicinity of the barracks building and former location of UST-1. Groundwater samples were collected from four wells associated with the study area (MW-1, MW-4, MW-5 and MW-6), and the background well (MW-2). All of the sampling locations, with the exception of background well MW-2, are shown on Figure 5-1; MW-2 is depicted on Figure 3-4. The results are described below, and are summarized in Tables 5-1 and 5-2, at the end of Section 5.0.

5.1.4.1 Soil. Two soil samples were selected from each of the six borings from the intervals suspected to have the highest level of contamination, as determined by field screening. Soil samples were analyzed by a laboratory for VOCs by SW846 Method 8260 [including methyl-tert-butyl-ether (MTBE)], SVOCs by SW846 Method 8270A, and VPH and EPH by Draft MADEP Method 1.0. Depths were selected for VOC and VPH samples based upon headspace screening, conducted in accordance with the MADEP Jar Headspace Analytical Screening Procedure (MADEP, 1994). Whenever possible, samples for SVOC and EPH analyses were taken from the same depth intervals as the samples for VOC and VPH analyses.

However, in some instances, additional sample volume was required for the SVOC and EPH analyses. In these cases, samples collected from adjacent depths were composited with the sample collected from the depth initially selected for VOC/VPH analysis. The soil samples which were collected are as follows:

- SB-15 was placed in the front of the barracks building as close to the building as possible in order to determine whether contamination had traveled under or around the barracks building in this direction. Soil samples were selected for VOC and VPH analyses from 6-8 and 13-5 feet below ground surface. Sample depths for SVOC and EPH volatiles were 4-8 and 13-15 feet below ground surface. A field duplicate was collected for VPH from the 6-8 foot interval.
- SB-16 was placed near the southeastern-most corner of the barracks building in order to determine whether contamination had traveled under or around the building in this direction. Soil samples were selected for VOC and VPH analyses from 4-6 and 8-10 feet below ground surface. Sample depths for SVOC and EPH analyses were 2-6 and 8-10 feet below ground surface.
- SB-17 was placed on the north side, or back, of the barracks building, to determine the limit of contamination along the preferential pathway of the building in this direction. Soil samples were selected for all four analyses from 0-2 and 5-7 feet below ground surface. A field duplicate was selected from the 5-7 foot interval for the VOC and SVOC analyses.
- SB-18 was placed along the sewer line to evaluate the previously estimated extent of contamination along this preferential pathway. This boring was advanced three times at three adjacent locations, but refusal was encountered each time at approximately nine feet below ground surface. Therefore, only one set of samples was collected from this boring for laboratory analysis. Soil samples were collected for VOC and VPH analyses from 4-6 feet below ground surface, and for SVOC and EPH analyses from 4-8 feet below ground surface. A field duplicate was collected for EPH from the 4-8 foot interval.
- SB-19 was placed upgradient, northeast, of the release area to evaluate the estimated extent of contamination in that direction. Soil samples were selected for VOC and VPH analyses from 4-6 and 6-7 feet below the ground surface. Samples were selected for SVOC and EPH analyses from 2-6 and 6-7 feet below the ground surface.

- SB-20 was placed in the immediate vicinity of the former location of UST-1 in the area suspected to have the most elevated levels of contamination in order to evaluate the worst-case site conditions. Soil samples were selected for VOC and VPH analyses from 2-4 and 4-6 feet below ground surface. Samples were selected for SVOC and EPH analyses from 0-4 and 4-6 feet below the ground surface.

During sampling, staining and a strong petroleum odor were apparent at SB-20 from approximately 5 feet to less than 15 feet below ground surface. This boring was in the area of highest suspected contamination. Staining and strong petroleum odor were also apparent at SB-19, farther northeast, in the 6-7 foot interval, however the next interval (13-15 feet) was not stained. Some slight staining was also visible at SB-15 (13-15 foot interval), SB-16 (8-10 foot interval), and SB-18 (4-8 foot interval).

VOCs were detected in samples collected from three borings at three different intervals: SB-15 from 13-15 feet, SB-19 from 6-7 feet, and SB-20 from 4-6 feet. Compounds detected are presented in Table 5-1. Concentrations were most elevated in the sample from SB-19, ranging from 13 $\mu\text{g/Kg}$ (isopropylbenzene) to 200 $\mu\text{g/Kg}$ (naphthalene). Concentrations in the sample from SB-15 ranged from 1 to 13 $\mu\text{g/Kg}$, and those in the sample from SB-20 ranged from 2 to 18 $\mu\text{g/Kg}$. None of the VOC concentrations exceeded the Method 1 S-1/GW-3 Standards.

One or more SVOCs were detected in all samples; the compounds detected are presented in Table 5-1. Concentrations were most elevated in the sample collected from SB-20 (4-6 feet). Concentrations ranged from 98 $\mu\text{g/Kg}$ (fluoranthene) to 25,000 $\mu\text{g/Kg}$ (2-methylnaphthalene). SVOC concentrations were also comparatively elevated in the sample from SB-19 (6-7 feet). Concentrations ranged from 14 $\mu\text{g/Kg}$ (benzo(a)anthracene) to 1,400 $\mu\text{g/Kg}$ (fluorene).

VPH and EPH were also detected in all samples collected. Concentrations were most elevated in the samples collected from SB-19 (6-7 feet) and SB-20 (4-6 feet), and exceeded the standard for two of the carbon ranges (C9-C10 aromatics and C9-C18 aliphatics).

5.1.4.2. Groundwater. In May 1996, groundwater samples were collected from MW-1, MW-4, MW-5 and MW-6. Samples were collected using low flow methods, and analyzed for VOCs by SW846 Method 8260. Chlorinated VOCs were detected in MW-4, MW-5, and MW-6. Concentrations ranged from 0.5 to 1.0 $\mu\text{g/L}$; all detected concentrations were below the Method 1 GW-3 Standards. No compounds indicative of petroleum contamination were detected.

5.1.5 Summary of Contamination at UST-1. Based on the results of analyses conducted in the vicinity of UST-1, contamination in this area is limited to the presence of petroleum hydrocarbons in subsurface soils, generally at depths of about 6-12 ft and extending outward from the previous location of UST-1. Analytical data indicates that contamination has either traveled under the barracks building, or along the footprint of the building. There is no evidence of groundwater contamination above Method 1 GW-3 standards in the vicinity, or downgradient of, the previous location of UST-1.

5.2 Summary of Analytical Results at UST-2

The results of sampling and analyses conducted in the vicinity of UST-2 are described below. Monitoring locations are shown in Figure 5-2. Monitoring locations which represent soil that has been removed from the site are not presented, since they are no longer representative of site conditions. Soil analytical data is summarized in Table 5-3; groundwater analytical data is summarized in Table 5-4. Both of these tables are located at the end of Section 5.0.

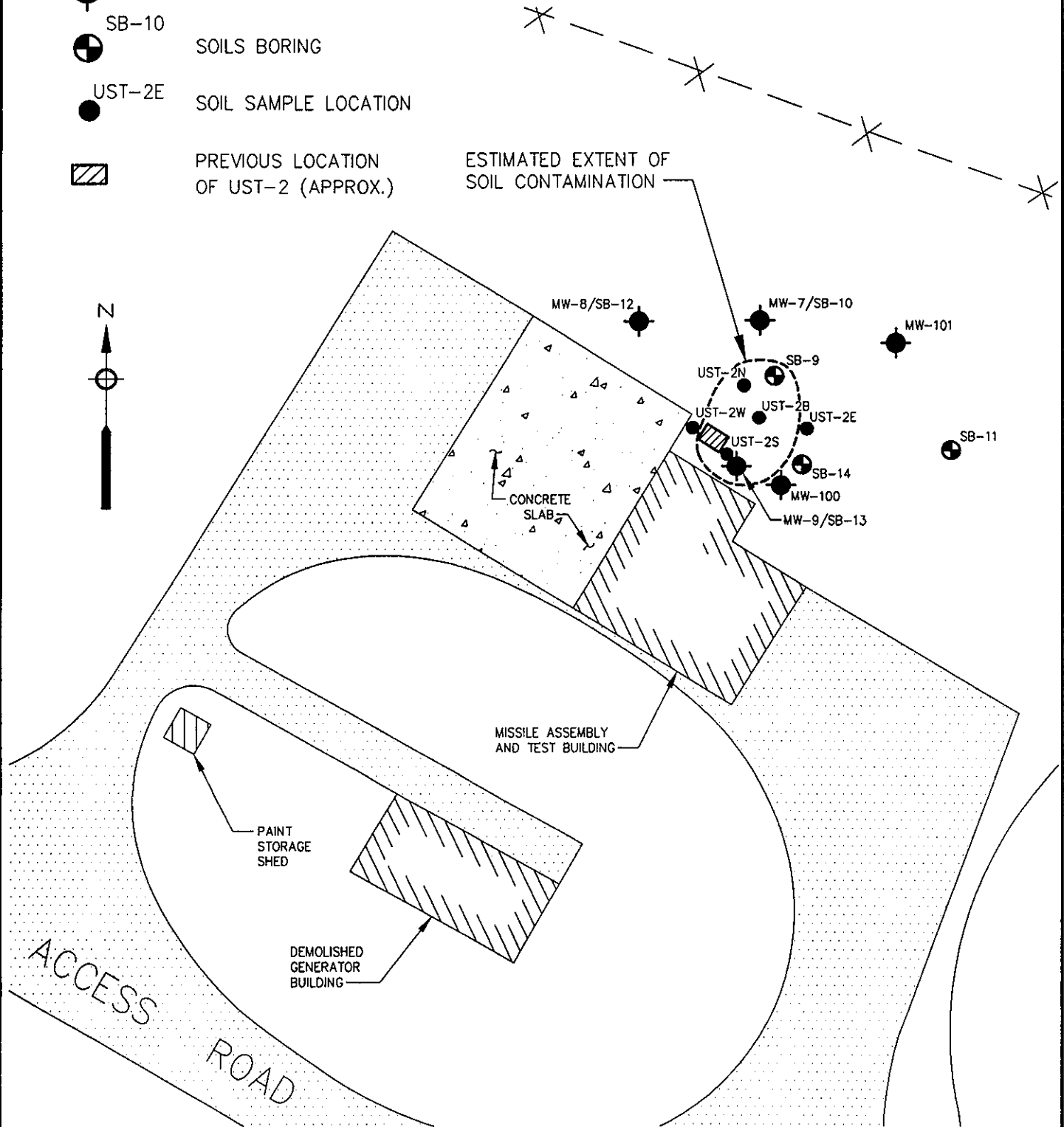
5.2.1 Analyses from May 1992 Excavation. In May 1992, a second attempt was made to excavate the contaminated soils from the vicinity of UST-2. After excavating approximately 38 cubic yards of additional soil, samples were taken from the bottom (UST-2B) and from the north, east, south and west side walls (UST-2N, UST-2E, UST-2S and UST-2W, respectively), and analyzed for TPH. The locations of these samples are shown on Figure 5-2. The results of these analyses, summarized in Table 5-3, show residual TPH concentrations

LEGEND:

- PROPERTY LINE
- x—x— EXIST. FENCE
- MW-1
● GROUNDWATER MONITORING WELL
- SB-10
⊕ SOILS BORING
- UST-2E
● SOIL SAMPLE LOCATION
- ▨ PREVIOUS LOCATION OF UST-2 (APPROX.)

NOTE:

MONITORING LOCATIONS FROM 1994 AND 1996 ARE BASED UPON THE 1994 SURVEY BY GUERRIERE & HALNON, INC. AND THE 1996 SURVEY BY M & E. LOCATION OF ADDITIONAL OBJECTS IS APPROXIMATE.



TOPSFIELD, MASSACHUSETTS

FIGURE 5-2 MONITORING LOCATIONS AND ESTIMATED EXTENT OF SOIL CONTAMINATION ASSOCIATED WITH UST-2

SCALE: 1"=30'

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X

along the south side wall (UST-2S) and north side wall (UST-2N). The concentration in UST-2N (1,100 mg/Kg) exceeds the TPH Method 1 S-1/GW-3 Standard of 800 mg/Kg. These samples are considered to be representative of current site conditions, since no further excavation has occurred.

5.2.2 Analyses from 1994 Site Investigation. During the 1994 investigation, samples collected in the vicinity of or relevant to UST-2 included two soil samples from each of six boring locations (SB-9 through SB-14) and three groundwater samples (MW-7, MW-8, MW-9). The locations of these samples are shown on Figure 5-2. The results are summarized in Tables 5-3 and 5-4 and described below.

5.2.2.1 Soils. Two soil samples were collected from each of six soil borings drilled in the vicinity of UST-2 (SB-9 through SB-14). Soil samples were analyzed for a selected list of VOCs (BTEX) by SW846 Method 8020, a selected list of SVOCs (naphthalene, phenanthrene and 2-methylnaphthalene) by SW846 Method 8270, and TPH by SW846 Method 418.1. These parameters are suggested by MADEP policy #WSC-401-91 for a release of #2 fuel oil (MADEP, 1991b). Depths selected for VOC analyses were based on field screening results. Whenever possible, samples for SVOC and TPH analyses were taken from the same depth interval as the samples for VOC analysis. However, in several instances additional sample volume was required for the SVOC and TPH analyses. In these cases, samples collected from adjacent depths were composited with the sample collected from the depth initially selected for VOC analyses. Therefore, the sample depths listed on Table 5-3 for these two analyses differ from those listed for the corresponding VOC analyses. The soil samples which were collected are as follows:

- SB-9 was drilled along the water line in the previous location of UST-2N, an area identified as having high residual TPH contamination. Soil samples selected for VOC analysis were from 0-2 and 15-15.9 feet below the surface. The sample depths for SVOC and TPH analyses were 0-2 and 15-20 feet.

- SB-10 was drilled approximately 12 feet north of SB-9, to determine the extent of contamination in the apparent down-gradient direction. Soil samples collected for VOC analysis were from 8.5-10.5 and 15-17 feet below the surface. The sample depths for SVOC and TPH analyses were 6-10.5 and 15-17 feet.
- SB-11 was drilled along the waterline, a suspected preferential pathway downgradient of SB-9, to confirm the extent of contamination. Samples were collected for VOC analysis from 4-6 and 8-10 feet below the surface. The sample depths for SVOC and TPH analyses were 4-8 and 8-10 feet.
- SB-12 was drilled approximately 30 feet west of SB-9, and was also intended to confirm the extent of contamination. Samples selected for VOC, SVOC and TPH analyses were from 0-2 and 2-4 feet below the surface.
- SB-13 was drilled beneath the walkway at the building foundation, south of the previous area of excavation, to confirm the southern limit of contamination. Samples selected for VOC analysis were from 4-6 and 8-10 feet below the surface. The sample depths for SVOC and TPH analyses were 4-6 and 6-10 feet.
- SB-14 was drilled approximately 5 feet southeast of the previous area of excavation to confirm the extent of contamination in that direction. Samples were selected for VOC analysis from 2-4 and 8-10 feet below the surface. The sample depths for SVOC and TPH analyses were 2-4 and 4-10 feet. A field duplicate was collected from this boring at the deeper sample location.

During the advancement of all borings (SB-9 through SB-14) no odors or staining were observed. No VOCs or SVOCs were detected in any of the samples submitted for laboratory analyses. TPH was detected in all samples, generally at low concentrations and consistently below the Method 1 S-1/GW-3 Standard of 800 mg/Kg. The highest TPH concentrations were reported in SB-9 and SB-13. These borings were drilled at the boundary of the previous excavation.

5.2.2.2 Groundwater. Groundwater monitoring wells MW-7, MW-8 and MW-9 were installed in borings SB-10, SB-12 and SB-13, respectively. Groundwater samples were collected from each well and analyzed for a selected list of VOCs (BTEX), a selected list of

SVOCs (naphthalene, 2-methylnaphthalene, and phenanthrene), and TPH. No detectable concentrations were reported for any of these parameters for any of the samples. However, the laboratory noted that several chlorinated VOCs were detected in all three of the groundwater samples. The approximate concentrations of these compounds are shown on Table 5-4.

Since these chlorinated compounds were all non-target analytes, the laboratory did not run standards or perform specific quality control measures related to these chlorinated compounds. Therefore, the concentrations could not be validated and are reported as approximations. Although only approximate, the concentrations do not exceed the Method 1 GW-3 Standards.

5.2.3 Analyses from 1996 Site Investigation. During the 1996 investigation, a soil vapor survey was conducted in the vicinity of the missile assembly and test building, in order to locate a possible source for the chlorinated VOCs detected in groundwater and to select locations for additional borings and monitoring wells. None of the compounds of interest were detected in soil vapor at concentrations exceeding background, indicating no identifiable source for the contamination. As a result, the data was not instrumental in selecting additional monitoring locations. Therefore, prior to advancing additional borings, the existing groundwater monitoring wells were resampled and analyzed for VOCs. The analytical results confirmed the presence of chlorinated VOCs in groundwater in the vicinity of the missile assembly and test building.

Based on the confirmed presence of chlorinated VOCs, two soil borings were installed to define the vertical and horizontal extent of contamination. One of the borings was shallow and one was deep overburden. Two soil samples were collected for laboratory analysis for VOCs from each of the two soil borings, based upon field screening of soils using a portable GC. One sample from each boring was also collected for grain size analysis. The borings were then converted to monitoring wells, the wells were developed, sampled, permeability tested, and surveyed. Groundwater samples were submitted for laboratory analysis for VOCs. The

results of the VOC analyses are summarized in Tables 5-3 and 5-4 at the end of Section 5.0, and are described below. Results of the grain size analyses are presented in Section 4.8.

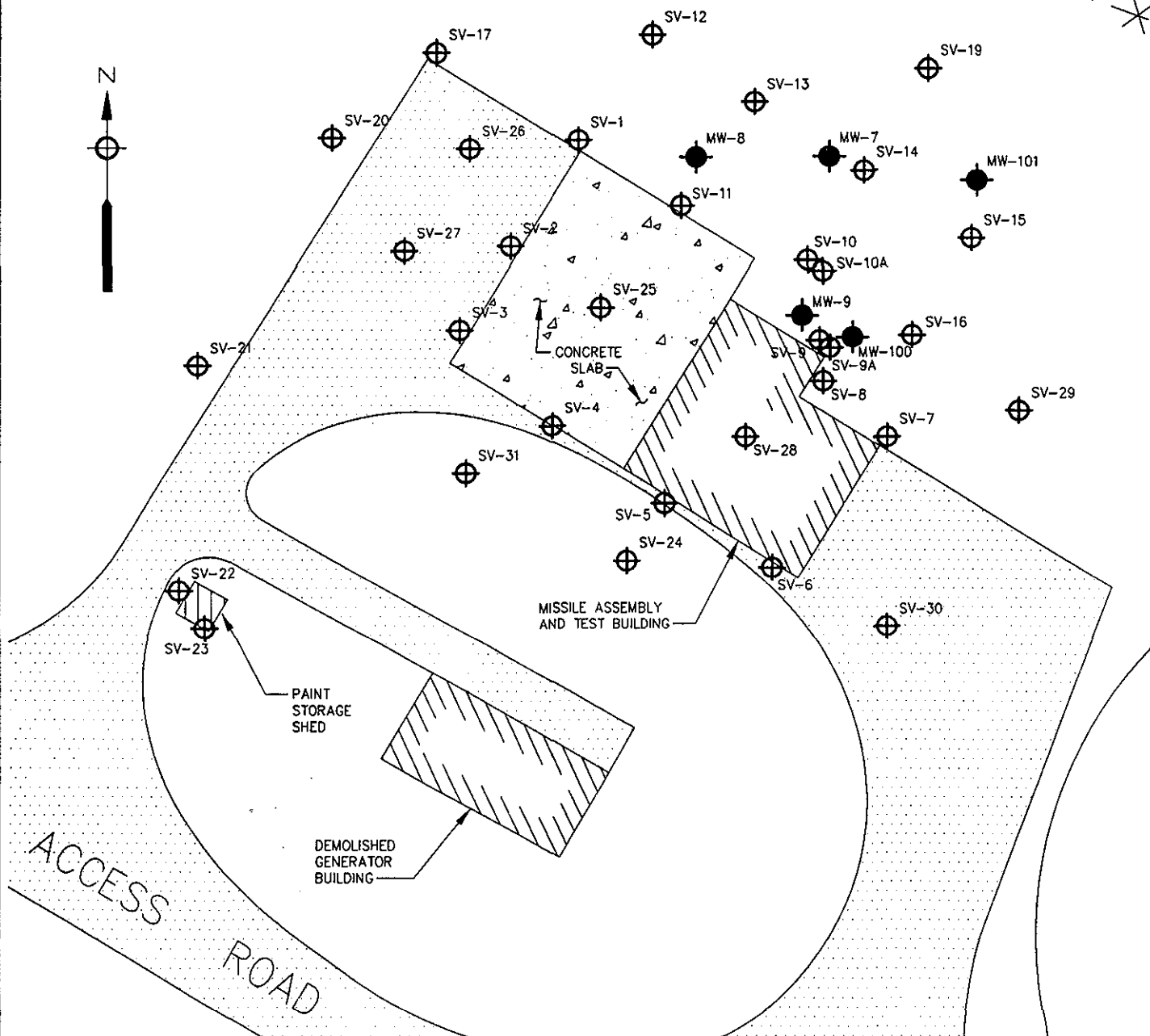
5.2.3.1 Soil Vapor. Soil vapor was collected for field screening from 32 locations. As indicated in Figure 5-3, points were advanced below the building floor, through the adjoining concrete pad and the surrounding paved areas, and into the soils surrounding the missile assembly and test building. Sample collection depths were approximately 1 to 3 feet below ground surface. Samples were analyzed using a Hewlett Packard 5890 GC with a 10.2 eV PID lamp. Data were processed using a personal computer loaded with Hewlett Packard Chemstation software, interfaced with a printer. Selected target analytes were 1,1-dichloroethene, trans-1,2-dichloroethene, cis-1,2-dichloroethene, trichloroethene, and tetrachloroethene. None of the target analytes were detected at concentrations above practical quantitation limits.

5.2.3.2 Soil. One deep overburden soil boring was drilled to define the vertical extent of contamination, and one shallow overburden boring was drilled to define the extent of contamination in the suspected downgradient direction. The deep boring, SB-100, was located next to MW-9, the monitoring well with the most elevated levels of chlorinated VOCs in groundwater. Soil samples were analyzed onsite using the GC and software described above and an electron capture detector (ECD). Soil samples were analyzed for the same compounds as the soil vapor, as well as 1,1,1-trichloroethane. Second column confirmation was provided using the ECD for two of the compounds also detectable by the PID. Based on the results, the boring was advanced until contaminants were no longer detected, thereby defining the vertical extent of contamination. Soil screening was also conducted during installation of the shallow overburden boring, SB-101. Based on screening results, two soil samples were selected from each soil boring for laboratory analysis. A third sample was selected from the bottom of the deep boring to confirm that the vertical extent of contamination had been exceeded.

LEGEND:

- PROPERTY LINE
- x-x- EXIST. FENCE
- MW-1 GROUNDWATER MONITORING WELL
- SV-1 SOIL VAPOR SAMPLING POINT

NOTE:
MONITORING LOCATIONS FROM 1994
AND 1996 ARE BASED UPON THE 1994
SURVEY BY GUERRIERE & HALNON, INC.
AND THE 1996 SURVEY BY M & E. LOCATIONS
OF ADDITIONAL OBJECTS, INCLUDING SOIL
VAPOR SAMPLING POINTS, ARE APPROXIMATE.



TOPSFIELD, MASSACHUSETTS
FIGURE 5-3 SOIL VAPOR
SAMPLING POINTS



METCALF & EDDY

SCALE: 1"=30'

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In SB-100, soil samples were selected from the 7-9 foot interval and the 22-24 foot interval based on screening results, and from the last split-spoon sample at 42-44 feet. In SB-101, soil samples were selected from the 9-11 and 16-18 foot intervals, and a field duplicate was collected at the 9-11 foot interval.

Laboratory analytical results indicated 1,1-dichloroethene and 1,1-dichloroethane were present in SB-100 (22-24 feet) at concentrations of 2 $\mu\text{g}/\text{Kg}$ each. These concentrations are less than the Method 1 S-1/GW-3 Standards for these compounds. No other compounds were detected in soils collected from these two borings.

5.2.3.3. Groundwater. During the first groundwater sampling event conducted in 1996, groundwater samples were collected in the vicinity of the missile assembly and test building from existing wells MW-7 through MW-9. During the second sampling event, groundwater samples were collected from newly installed wells MW-100 and MW-101. During both events, samples were collected using low-flow methods, and submitted to a laboratory for VOC analysis by SW846 Method 8260. During the first sampling event, the presence of previously identified chlorinated VOCs in groundwater was confirmed. Concentrations were most elevated in MW-9, immediately behind the missile assembly test building, and ranged from 5 $\mu\text{g}/\text{L}$ (1,1-dichloroethane) to 130 $\mu\text{g}/\text{L}$ (1,1,1-trichloroethane). Concentrations of chlorinated VOCs in the other wells ranged from nondetect to approximately 1 $\mu\text{g}/\text{L}$. All detected concentrations were below the Method 1 GW-3 standards.

During the second groundwater sampling event, no detectable concentrations of VOCs were reported. Therefore, the extent of chlorinated VOC contamination was defined vertically by MW-100, which is screened from 34 to 44 feet below ground surface, and horizontally in the direction of MW-101. Compounds associated with petroleum contamination were not detected.

5.2.4 Summary of Contamination at UST-2. Based on the results of analyses conducted in the vicinity of UST-2, contamination in this area of the disposal site is limited to an isolated area of petroleum hydrocarbons in subsurface soil and the presence of low levels of chlorinated VOCs in the groundwater.

After two attempts to excavate petroleum contaminated soil, residual TPH was detected in only one of the confirmatory samples. Additional sampling in the immediate vicinity of the residual contamination did not confirm the presence of elevated TPH concentrations. Further response actions are not warranted.

The extent of groundwater contamination is limited to the upper 34 feet of the aquifer in the vicinity of monitoring well MW-9. This contamination is likely the result of historical activities at the missile assembly and test building; no current source of chlorinated VOCs was detected. Concentrations of chlorinated VOCs in wells surrounding MW-9 diminish to much lower levels (approximately 1 ppb) in all directions. This decrease in concentration could be due to one or more natural attenuation processes, such as volatilization, chemical or biological degradation, or dispersion, although sufficient data is not available to confirm this possibility. If natural attenuation is occurring, it could be expected to further diminish concentrations over time. This possible attenuation, together with consideration of the currently low VOC concentrations and no identifiable existing source, support the conclusion that further response actions are not required.

Table 5-1 (Page 1 of 6). Summary of Soil Analytical Results Relevant to UST-1

Parameter (a)	Method 1 S-1/GW-3 Standard (b)	Maximum Detected Concentration	Location of Maximum	1987 Confirmation Study							1991 Study B-4
				UT-1	D-0 Bkgnd	MW-1	MW-4	MW-4D	TF-1	TF-1D	
TPH (mg/Kg)	800	3,880	SB-2	320	NA	43	16	20	65	32	450
VPH (mg/Kg) (c)				NA	NA	NA	NA	NA	NA	NA	NA
C5-C8 aliphatics	100	11.69	SB-19								
C9-C12 aliphatics	1,000	203.5	SB-19								
C9-C10 aromatics	100	166.8	SB-19								
EPH (mg/Kg) (d)				NA	NA	NA	NA	NA	NA	NA	NA
C9-C18 aliphatics	1,000	1,025.0	SB-19								
C19-C36 aliphatics	2,500	112.8	SB-19								
C11-C22 aromatics	800	443.6	SB-19								
VOCs (mg/Kg)					NA						
Acetone	60	0.250	MW-1	<0.100		0.250	<0.100	<0.100	<0.100	<0.100	
Benzene	40	<0.30*		<0.05		<0.05	<0.05	<0.05	<0.05	<0.05	
Toluene	500	<0.30*		<0.05		<0.05	<0.05	<0.05	<0.05	<0.05	
Ethylbenzene	500	0.12*	SB-3	<0.05		<0.05	<0.05	<0.05	<0.05	<0.05	
Total xylenes	500	0.23*	SB-3	<0.05		<0.05	<0.05	<0.05	<0.05	<0.05	
Sec-Butylbenzene	NS	0.058	SB-19	NA		NA	NA	NA	NA	NA	
Isopropylbenzene	NS	0.013	SB-19	NA		NA	NA	NA	NA	NA	
p-Isopropyltoluene	NS	0.041	SB-19	NA		NA	NA	NA	NA	NA	
Naphthalene	100	0.2	SB-19	NA		NA	NA	NA	NA	NA	
n-Propylbenzene	NS	0.027	SB-19	NA		NA	NA	NA	NA	NA	
1,2,4-Trimethylbenzene	NS	0.008	SB-15	NA		NA	NA	NA	NA	NA	
1,3,5-Trimethylbenzene	NS	0.011	SB-15	NA		NA	NA	NA	NA	NA	
SVOCs (mg/Kg)				NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	100	3.9	SB-20								
2-Methylnaphthalene	500	25	SB-20								
Phenanthrene	100	6.8	SB-2								
Phenol	500	0.058	SB-18								
Acenaphthylene	100	0.052	SB-15								
Acenaphthene	1,000	1.4	SB-20								
Dibenzofuran	NS	0.97	SB-20								
Fluorene	1,000	2.0	SB-20								
N-Nitrosodiphenylamine	NS	1.8	SB-20								
Anthracene	1,000	0.56	SB-20								
Fluoranthene	1,000	0.74	SB-15								
Pyrene	700	0.66	SB-15								
Butylbenzylphthalate	NS	0.032	SB-20								
Benzo(a)anthracene	0.7	0.36	SB-15								
Chrysene	7	0.37	SB-15								
bis(2-Ethylhexyl)phthalate	200	0.11	SB-16								
Di-n-octylphthalate	NS	0.15	SB-16								
Benzo(b)fluoranthene	0.7	0.39	SB-15								
Benzo(k)fluoranthene	7	0.38	SB-15								
Benzo(a)pyrene	0.7	0.36	SB-15								
Indeno(1,2,3-cd)pyrene	0.7	0.17	SB-15								
Dibenzo(a,h)anthracene	0.7	0.01	SB-20								
Benzo(g,h,i)perylene	1,000	0.16	SB-15								
Metals (mg/Kg)											NA
Aluminum	NS	16,000	D-0	12,000	16,000	13,000	12,000	12,000	13,000	14,000	
Arsenic	30	11	MW-1	10	10	11	9	10	11	10	
Barium	1,000	59	MW-4D	48	38	50	53	59	42	52	
Calcium	NS	3,400	TF-1D	2,300	710	3,200	2,300	2,500	2,700	3,400	
Chromium	1,000	56	D-0	39	56	31	48	51	28	18	
Copper	NS	45	MW-4D	32	38	37	44	45	30	25	
Iron	NS	27,000	MW-4	23,000	25,000	25,000	27,000	27,000	20,000	18,000	
Lead	300	86	MW-4D	23	12	22	85	86	35	20	
Magnesium	NS	5,700	MW-1	4,200	3,200	5,700	4,500	4,000	4,700	4,300	
Manganese	NS	460	MW-4D	350	330	400	420	460	380	200	
Mercury	20	0.4	MW-4/TF-1D	0.3	0.2	0.3	0.4	0.3	0.3	0.4	
Nickel	300	29	MW-1	21	27	29	24	26	22	13	
Silver	100	1	MW-1	<1	<1	1	<1	<1	<1	<1	
Sodium	NS	330	D-0	85	330	110	110	190	78	130	
Zinc	2,500	87	MW-4	48	44	57	87	76	61	45	

Table 5-1 (Page 2 of 6). Summary of Soil Analytical Results Relevant to UST-1

Parameter (a)	Method 1 S-1/GW-3 Standard (b)	1994 Site Investigation							
		SB-1 (6-8)	SB-1 (10-12)	SB-2 (6-8)(2-8)	SB-2 (10-12)	SB-3 (4-6)(4-8)	SB-3 (10-12)	SB-4 (8-10)(6-10)	SB-4 (10-12)(10-14)
TPH (mg/Kg)	800	<3.6	126	515	3880	493	37.3	140	134
VPH (mg/Kg) (c)		NA	NA	NA	NA	NA	NA	NA	NA
C5-C8 aliphatics	100								
C9-C12 aliphatics	1,000								
C9-C10 aromatics	100								
EPH (mg/Kg) (d)		NA	NA	NA	NA	NA	NA	NA	NA
C9-C18 aliphatics	1,000								
C19-C36 aliphatics	2,500								
C11-C22 aromatics	800								
VOCs (mg/Kg)									
Acetone	60	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	40	<0.28*	<0.055*	<0.06*	<0.0043*	<0.0055*	0.0062*	<0.0011J	<0.0011J
Toluene	500	<0.28*	<0.055*	<0.06*	<0.0043*	<0.0055*	<0.0054*	<0.0011J	<0.0011J
Ethylbenzene	500	<0.28*	<0.055*	<0.06*	<0.0043*	<0.0055*	0.12*	<0.0011J	<0.0011J
Total xylenes	500	<0.28*	<0.055*	<0.06*	<0.0043*	<0.0055*	0.23*	<0.0011J	<0.0011J
Sec-Butylbenzene	NS	NA	NA	NA	NA	NA	NA	NA	NA
Isopropylbenzene	NS	NA	NA	NA	NA	NA	NA	NA	NA
p-Isopropyltoluene	NS	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	100	NA	NA	NA	NA	NA	NA	NA	NA
n-Propylbenzene	NS	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	NS	NA	NA	NA	NA	NA	NA	NA	NA
1,3,5-Trimethylbenzene	NS	NA	NA	NA	NA	NA	NA	NA	NA
SVOCs (mg/Kg)									
Naphthalene	100	1.5	<0.36	<0.38	1.7	<0.37	<0.37	<0.37	<0.35
2-Methylnaphthalene	500	11	0.67	<0.38	24	<0.37	1.3	<0.37	<0.35
Phenanthrene	100	2.2	1.3	<0.38	6.8	0.6	0.66	<0.37	<0.35
Phenol	500	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthylene	100	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	1,000	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran	NS	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	1,000	NA	NA	NA	NA	NA	NA	NA	NA
N-Nitrosodiphenylamine	NS	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	1,000	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	1,000	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	700	NA	NA	NA	NA	NA	NA	NA	NA
Butylbenzylphthalate	NS	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	0.7	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	7	NA	NA	NA	NA	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	200	NA	NA	NA	NA	NA	NA	NA	NA
Di-n-octylphthalate	NS	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	0.7	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	7	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	0.7	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	0.7	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	0.7	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene	1,000	NA	NA	NA	NA	NA	NA	NA	NA
Metals (mg/Kg)		NA	NA	NA	NA	NA	NA	NA	NA
Aluminum	NS								
Arsenic	30								
Barium	1,000								
Calcium	NS								
Chromium	1,000								
Copper	NS								
Iron	NS								
Lead	300								
Magnesium	NS								
Manganese	NS								
Mercury	20								
Nickel	300								
Silver	100								
Sodium	NS								
Zinc	2,500								

Table 5-1 (Page 3 of 6). Summary of Soil Analytical Results Relevant to UST-1

Parameter (a)	Method 1 S-1/GW-3 Standard(b)	1994 Site Investigation									
		SB-5 (8-10)(2-10)	SB-5D (8-10)(2-10)	SB-5 (12-14)(10-16)	SB-5D (12-14)(10-16)	SB-6 (4-6)(4-8)	SB-6 (6-8)(15-17)	SB-7 (8-10)	SB-7 (15-17)	SB-8 (2-4)	SB-8 (20-22)
TPH (mg/Kg)	800	201J	358J	150	107	8.7	30.1	741	32.1	7.6	19.2
VPH (mg/Kg) (c)		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C5-C8 aliphatics	100										
C9-C12 aliphatics	1,000										
C9-C10 aromatics	100										
EPH (mg/Kg) (d)		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C9-C18 aliphatics	1,000										
C19-C36 aliphatics	2,500										
C11-C22 aromatics	800										
VOCs (mg/Kg)											
Acetone	60	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	40	<0.0011J	<0.0011J	<0.0011J	<0.0011J	<0.0011	<0.0011	<0.30*	<0.055*	<0.0011	<0.0011
Toluene	500	<0.0011J	<0.0011J	<0.0011J	<0.0011J	<0.0011	<0.0011	<0.30*	<0.055*	<0.0011	<0.0011
Ethylbenzene	500	<0.0011J	<0.0011J	<0.0011J	<0.0011J	<0.0011	<0.0011	<0.30*	<0.055*	<0.0011	<0.0011
Total xylenes	500	<0.0011J	<0.0011J	<0.0011J	<0.0011J	<0.0011	<0.0011	<0.30*	<0.055*	<0.0011	<0.0011
Sec-Butylbenzene	NS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Isopropylbenzene	NS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
p-Isopropyltoluene	NS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	100	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
n-Propylbenzene	NS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	NS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3,5-Trimethylbenzene	NS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SVOCs (mg/Kg)											
Naphthalene	100	<0.36	<0.36	<0.36	<0.36	<0.37	<0.36	0.41J	<0.36	<0.36	<0.36
2-Methylnaphthalene	500	<0.36	<0.36	<0.36	<0.36	<0.37	<0.36	3.0J	<0.36	<0.36	<0.36
Phenanthrene	100	<0.36	<0.36	<0.36	<0.36	<0.37	<0.36	0.93	<0.36	<0.36	<0.36
Phenol	500	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthylene	100	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	1,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran	NS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	1,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
N-Nitrosodiphenylamine	NS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	1,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	1,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	700	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Butylbenzylphthalate	NS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	0.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	200	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Di-n-octylphthalate	NS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	0.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	0.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	0.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	0.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene	1,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Metals (mg/Kg)		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aluminum	NS										
Arsenic	30										
Barium	1,000										
Calcium	NS										
Chromium	1,000										
Copper	NS										
Iron	NS										
Lead	300										
Magnesium	NS										
Manganese	NS										
Mercury	20										
Nickel	300										
Silver	100										
Sodium	NS										
Zinc	2,500										

Table 5-1 (Page 4 of 6). Summary of Soil Analytical Results Relevant to UST-1

Parameter (a)	Method 1 S-1/GW-3 Standard (b)	1996 Pre-RAM Investigation						
		SB-15 (6-8)(4-8)	SB-15 (13-15)	SB-15D (6-8)	SB-16 (4-6)(2-6)	SB-16 (8-10)	SB-17 (0-2)	SB-17 (5-7)
TPH (mg/Kg)	800	NA	NA	NA	NA	NA	NA	NA
VPH (mg/Kg) (c)								
C5-C8 aliphatics	100	6.383J	7.065J	5.732J	6.107J	5.668J	5.082J	5.158J
C9-C12 aliphatics	1,000	19.58	15.74	3.71	2.332	13.12J	3.127	2.35
C9-C10 aromatics	100	21.34	15.28	5.519	0.81	13.08J	1.181	0.885
EPH (mg/Kg) (d)				NA				
C9-C18 aliphatics	1,000	38.13	289.4J		5.95J	47.93	3.268	3.063
C19-C36 aliphatics	2,500	11.5	32.48J		8.366J	13.19	5.286	3.091
C11-C22 aromatics	800	38.68	188.8J		14.09	28.77	12.36	8.899
VOCs (mg/Kg)				NA				
Acetone	60	<0.119	<0.116		<0.115	<0.115	<0.114	<0.114
Benzene	40	<0.006	<0.006		<0.006	<0.006	<0.006	<0.006
Toluene	500	<0.006	<0.006		<0.006	<0.006	<0.006	<0.006
Ethylbenzene	500	<0.006	0.001J		<0.006	<0.006	<0.006	<0.006
Total xylenes	500	<0.006	<0.006		<0.006	<0.006	<0.006	<0.006
Sec-Butylbenzene	NS	<0.006	0.012		<0.006	<0.006	<0.006	<0.006
Isopropylbenzene	NS	<0.006	0.004J		<0.006	<0.006	<0.006	<0.006
p-Isopropyltoluene	NS	<0.006	0.013		<0.006	<0.006	<0.006	<0.006
Naphthalene	100	<0.06	<0.058		<0.057	<0.057	<0.057	<0.057
n-Propylbenzene	NS	<0.006	0.009		<0.006	<0.006	<0.006	<0.006
1,2,4-Trimethylbenzene	NS	<0.006	0.008		<0.006	<0.006	<0.006	<0.006
1,3,5-Trimethylbenzene	NS	<0.006	0.011		<0.006	<0.006	<0.006	<0.006
SVOCs (mg/Kg)				NA				
Naphthalene	100	0.029J	0.067J		0.003J	<0.38	<0.39	<0.38
2-Methylnaphthalene	500	0.018J	0.64		<0.38	<0.38	<0.39	<0.38
Phenanthrene	100	<0.39	<0.36		<0.38	<0.38	<0.39	<0.38
Phenol	500	<0.39	<0.36		<0.38	<0.38	<0.39	<0.38
Acenaphthylene	100	0.052J	<0.36		<0.38	<0.38	<0.39	<0.38
Acenaphthene	1,000	0.016J	<0.36		<0.38	<0.38	<0.39	<0.38
Dibenzofuran	NS	<0.39	<0.36		<0.38	<0.38	<0.39	<0.38
Fluorene	1,000	0.033J	0.11J		<0.38	<0.38	<0.39	<0.38
N-Nitrosodiphenylamine	NS	<0.39	<0.36		<0.38	<0.38	<0.39	<0.38
Anthracene	1,000	0.033J	<0.36		<0.38	<0.38	0.003J	0.002J
Fluoranthene	1,000	0.74	0.007J		0.036J	0.025J	0.024J	0.019J
Pyrene	700	0.66	0.008J		0.033J	0.02J	0.025J	0.02J
Butylbenzylphthalate	NS	<0.39	<0.36		<0.38	<0.38	<0.39	<0.38
Benzo(a)anthracene	0.7	0.36J	<0.36		0.016J	<0.38	0.011J	0.009J
Chrysene	7	0.37J	<0.36		0.021J	<0.38	0.017J	0.015J
bis(2-Ethylhexyl)phthalate	200	<0.39	<0.36		0.11J	<0.38	<0.39	<0.38
Di-n-octylphthalate	NS	0.074J	0.043J		0.15J	<0.38	0.006J	0.012J
Benzo(b)fluoranthene	0.7	0.39	<0.36		0.017J	<0.38	0.013J	0.011J
Benzo(k)fluoranthene	7	0.38J	<0.36		0.019J	<0.38	0.014J	0.012J
Benzo(a)pyrene	0.7	0.36J	<0.36		0.015J	<0.38	0.013J	0.01J
Indeno(1,2,3-cd)pyrene	0.7	0.17J	<0.36		<0.38	<0.38	0.010J	0.008J
Dibenzo(a,h)anthracene	0.7	<0.39	<0.36		<0.38	<0.38	<0.39	0.003J
Benzo(g,h,i)perylene	1,000	0.16J	<0.36		<0.38	<0.38	0.010J	0.009J
Metals (mg/Kg)		NA	NA	NA	NA	NA	NA	NA
Aluminum	NS							
Arsenic	30							
Barium	1,000							
Calcium	NS							
Chromium	1,000							
Copper	NS							
Iron	NS							
Lead	300							
Magnesium	NS							
Manganese	NS							
Mercury	20							
Nickel	300							
Silver	100							
Sodium	NS							
Zinc	2,500							

Table 5-1 (Page 5 of 6). Summary of Soil Analytical Results Relevant to UST-1

Parameter (a)	Method 1 S-1/GW-3 Standard (b)	1996 Pre-RAM Investigation						
		SB-17D (5-7)	SB-18 (4-6)(4-8)	SB-18D (4-8)	SB-19 (4-6)(2-6)	SB-19 (6-7)	SB-20 (2-4)(0-4)	SB-20 (4-6)
TPH (mg/Kg)	800	NA	NA	NA	NA	NA	NA	NA
VPH (mg/Kg) (c)		NA		NA				
C5-C8 aliphatics	100		7.086J		5.938J	11.69J	4.295J	11.54J
C9-C12 aliphatics	1,000		7.978		2.013	203.5	2.762	137.3
C9-C10 aromatics	100		9.442		0.685	166.8	0.962	129.0
EPH (mg/Kg) (d)		NA						
C9-C18 aliphatics	1,000		4.392J	13.539J	4.522J	1,025.0	9.686	839.0
C19-C36 aliphatics	2,500		2.198J	6.755J	2.74J	112.8	8.617	91.05
C11-C22 aromatics	800		12.2J	18.55	12.03J	443.6J	19.0	324.6
VOCs (mg/Kg)				NA				
Acetone	60	<0.114	<0.112		<0.112	<0.111	<0.120	<0.109
Benzene	40	<0.006	<0.006		<0.006	<0.006	<0.006	<0.005
Toluene	500	<0.006	<0.006		<0.006	<0.006	<0.006	<0.005
Ethylbenzene	500	<0.006	<0.006		<0.006	<0.006	<0.006	<0.005
Total xylenes	500	<0.006	<0.006		<0.006	<0.006	<0.006	<0.005
Sec-Butylbenzene	NS	<0.006	<0.006		<0.006	0.058	<0.006	<0.005
Isopropylbenzene	NS	<0.006	<0.006		<0.006	0.013	<0.006	<0.005
p-Isopropyltoluene	NS	<0.006	<0.006		<0.006	0.041	<0.006	0.018
Naphthalene	100	<0.057	<0.056		<0.056	0.200	<0.060	<0.005
n-Propylbenzene	NS	<0.006	<0.006		<0.006	0.027	<0.006	0.002J
1,2,4-Trimethylbenzene	NS	<0.006	<0.006		<0.006	<0.006	<0.006	<0.005
1,3,5-Trimethylbenzene	NS	<0.006	<0.006		<0.006	<0.006	<0.006	<0.005
SVOCs (mg/Kg)				NA				
Naphthalene	100	<0.38	0.004J		<0.38	1.0	0.025J	3.9J
2-Methylnaphthalene	500	<0.38	0.04J		<0.38	<0.75	0.01J	25
Phenanthrene	100	<0.38	<0.37		<0.38	<0.75	<0.38	<7.4
Phenol	500	<0.38	0.058J		<0.38	<0.75	<0.38	<7.4
Acenaphthylene	100	<0.38	<0.37		<0.38	<0.75	0.013J	<7.4
Acenaphthene	1,000	<0.38	<0.37		<0.38	<0.75	<0.38	1.4J
Dibenzofuran	NS	<0.38	<0.37		<0.38	<0.75	0.015J	0.97J
Fluorene	1,000	<0.38	0.007J		<0.38	1.4	0.01J	2.0J
N-Nitrosodiphenylamine	NS	<0.38	<0.37		<0.38	1.2	<0.38	1.8J
Anthracene	1,000	<0.38	<0.37		<0.38	0.34J	0.009J	0.56J
Fluoranthene	1,000	0.011J	0.002J		<0.38	0.061J	0.16J	0.098J
Pyrene	700	0.011J	<0.37		<0.38	0.12J	0.15J	0.14J
Butylbenzylphthalate	NS	<0.38	0.009J		<0.38	<0.75	0.032J	<7.4
Benzo(a)anthracene	0.7	0.004J	<0.37		<0.38	0.014J	0.046J	<7.4
Chrysene	7	0.008J	<0.37		<0.38	0.022J	0.074J	<7.4
bis(2-Ethylhexyl)phthalate	200	<0.38	<0.37		<0.38	<0.75	<0.38	<7.4
Di-n-octylphthalate	NS	0.013J	0.009J		0.022J	0.016J	<0.38	<7.4
Benzo(b)fluoranthene	0.7	0.006J	<0.37		<0.38	<0.75	0.047J	<7.4
Benzo(k)fluoranthene	7	0.007J	<0.37		<0.38	<0.75	0.057J	<7.4
Benzo(a)pyrene	0.7	0.006J	<0.37		<0.38	<0.75	0.053J	<7.4
Indeno(1,2,3-cd)pyrene	0.7	0.005J	<0.37		<0.38	<0.75	0.034J	<7.4
Dibenzo(a,h)anthracene	0.7	<0.38	<0.37		<0.38	<0.75	0.01J	<7.4
Benzo(g,h,i)perylene	1,000	0.005J	<0.37		<0.38	<0.75	0.034J	<7.4
Metals (mg/Kg)		NA	NA	NA	NA	NA	NA	NA
Aluminum	NS							
Arsenic	30							
Barium	1,000							
Calcium	NS							
Chromium	1,000							
Copper	NS							
Iron	NS							
Lead	300							
Magnesium	NS							
Manganese	NS							
Mercury	20							
Nickel	300							
Silver	100							
Sodium	NS							
Zinc	2,500							

Table 5-1 (Page 6 of 6). Summary of Soil Analytical Results Relevant to UST-1

NOTES:

- (a) - Results are generally presented for only those analytes which were detected in one or more of the samples presented in this table. In some cases, nondetect results are also presented as an indication of the analyses that were performed.
- (b) - MCP Method 1 Soil Category Standards for S-1 soil and GW-3 groundwater (310CMR 40.0975(6)); NS - no standard.
- (c) - VPH analysis also included six target VOC analytes (MTBE, BTEX and naphthalene). The targeted VPH analyte results are not presented in the table, since VOC analysis was also performed for those analytes and those VOC results are presented in the table. The targeted VPH analyte results are included in Appendix E.
- (d) - EPH analysis also included 17 targeted PAH analytes. The targeted EPH analyte results are not presented in the table, since SVOC analysis was also performed for those analytes and those SVOC results are presented in the table. The targeted EPH analyte results are included in Appendix E.

(2-4)(0-4) - Numbers in parentheses are sample depths. Where two intervals are presented, the first applies to the VPH and/or VOC fraction, the second to the remaining fractions.

Concentration exceeds MCP Method 1 S-1/GW-3 Standard.

< - Not detected at or above laboratory reporting limits. For each sample, the number shown is the reporting limit specific to that sample. For the maximum detected concentration, the number shown is the most elevated sample-specific reporting limit for all samples presented. Reporting limits specified by the laboratory are equivalent to Practical Quantitation Limits, also known as Estimated Quantitation Limits (EQL). EQLs are defined in the U.S. EPA Test Methods for Evaluating Solid Waste (SW-846) as follows: "The lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the MDL. However, it may be nominally chosen within these guidelines to simplify data reporting. For many analytes, the EQL analyte concentration is the lowest non-zero standard in the calibration curve." Note that the definition for MDL as used here can be obtained from 40 CFR Part 136, Appendix B.

NA - Not Analyzed.

J - Estimated

* - Fuel oil fingerprint detected late in the chromatogram; reporting limits for this sample are elevated.

Table 5-2 (Page 1 of 2). Summary of Groundwater Analytical Results Relevant to UST-1

Parameter (a)	Method 1 GW-3 Standard (b)	Maximum Detected Concentration	Location of Maximum	1987 Confirmation Study					1991 Study
				MW-1	MW-1D Field Dup.	MW-2 Bkgnd	MW-3	MW-4	B-4
TPH (ug/L)	20,000	91,000	B-4	300	<200	<200	600	<200	91,000
VOCs (ug/L)									NA
Benzene	7,000	<5.0		<5.0	<5.0	<5.0	<5.0	<5.0	
Toluene	50,000	<5.0		<5.0	<5.0	<5.0	<5.0	<5.0	
Ethylbenzene	4,000	<5.0		<5.0	<5.0	<5.0	<5.0	<5.0	
Total xylenes	50,000	<5.0		<5.0	<5.0	<5.0	<5.0	<5.0	
Methyl t-Butyl Ether	50,000	<5.0		NA	NA	NA	NA	NA	
Chlorinated VOCs (ug/L)									NA
1,1-Dichloroethene	50,000	<5.0		<5.0	<5.0	<5.0	<5.0	<5.0	
1,1-Dichloroethane	50,000	0.6	MW-4/MW-6	<5.0	<5.0	<5.0	<5.0	<5.0	
1,1,1-Trichloroethane	50,000	0.7	MW-5	<5.0	<5.0	<5.0	<5.0	<5.0	
Trichloroethene	20,000	1.0	MW-4	<5.0	<5.0	<5.0	<5.0	<5.0	
Methylene chloride	50,000	<10		<10	<10	<10	<10	<10	
SVOCs (ug/L)				NA	NA	NA	NA	NA	NA
Naphthalene	6,000	<11							
2-Methylnaphthalene	3,000	<11							
Phenanthrene	50	<11							
Metals (ug/L)									NA
Aluminum	NS	1,300	MW-1	1,300	400	300	<100	<100	
Arsenic	400	17	MW-3	<5	<5	<5	17	<5	
Barium	30,000	36	MW-3	20	14	10	36	23	
Cadmium	10	8	MW-3	6	5	<5	8	<5	
Calcium	NS	50,000	MW-4	30,000	28,000	18,000	25,000	50,000	
Chromium	2,000	30	MW-1	30	<10	<10	20	10	
Copper	NS	40	MW-1	40	20	20	30	<10	
Iron	NS	28,000	MW-3	1,500	460	350	28,000	50	
Lead	30	60	MW-1	60	<50	<50	<50	<50	
Magnesium	NS	12,000	MW-4	8,400	7,300	4,800	8,900	12,000	
Manganese	NS	6,900	MW-3	1,600	1,300	1,200	6,900	1,900	
Mercury	1	0.4	MW-2/MW-3	0.2	0.2	0.4	0.4	0.3	
Silver	7	10	MW-1	10	<10	<10	<10	<10	
Sodium	NS	25,000	MW-4	18,000	15,000	9,900	9,900	25,000	
Zinc	900	170	MW-1	170	120	160	80	160	

NOTES: (a) - Results are generally presented for only those analytes which were detected in one or more of the samples presented in this table.

In some cases, nondetect results are also presented as an indication of the analyses that were performed.

(b) - MCP Method 1 Standards for GW-3 groundwater (310CMR40.0974(2)); NS - No Standard.

Concentration detected exceeds Method 1 standard for GW-3 groundwater.

< - Not detected at or above laboratory reporting limits. For each sample, the number shown is the reporting limit specific to that sample. For the maximum detected concentration, the number shown is the most elevated sample-specific reporting limit for all of the samples presented. Reporting limits specified by the laboratory are equivalent to Practical Quantitation Limits, also known as Estimated Quantitation Limits (EQL). EQLs are defined in the U.S. EPA Test Methods for Evaluating Solid Waste (SW-846) as follows: "The lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the MDL. However, it may be nominally chosen within these guidelines to simplify data reporting. For many analytes, the EQL analyte concentration is the lowest non-zero standard in the calibration curve."

Note that the definition for MDL as used here can be obtained from 40 CFR Part 136, Appendix B.

J - Estimated.

NA - Not Analyzed

Table 5-2 (Page 2 of 2). Summary of Groundwater Analytical Results Relevant to UST-1

Parameter (a)	Method 1 GW-3 Standard (b)	1994 Site Investigation						1996 Supplemental Investigation					
		MW-1	MW-1 Field Dup.	MW-2 Bkgnd	B-4	MW-5	MW-6	MW-1	MW-2 Bkgnd	MW-2 Field Dup.	MW-4	MW-5	MW-6
TPH (ug/L)	20,000	<11,000	<11,000	<11,000	<11,000	<11,000	<11,000	NA	NA	NA	NA	NA	NA
VOCs (ug/L)													
Benzene	7,000	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Toluene	50,000	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Ethylbenzene	4,000	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Total xylenes	50,000	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Methyl t-Butyl Ether	50,000	NA	NA	NA	NA	NA	NA	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Chlorinated VOCs (ug/L)		NA	NA	NA	NA	NA	NA						
1,1-Dichloroethene	50,000							<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
1,1-Dichloroethane	50,000							<5.0	<5.0	<5.0	0.6J	<5.0	0.6J
1,1,1-Trichloroethane	50,000							<5.0	<5.0	<5.0	<5.0	0.7J	<5.0
Trichloroethene	20,000							<5.0	<5.0	<5.0	1.0J	0.5J	<5.0
Methylene chloride	50,000							<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
SVOCs (ug/L)								NA	NA	NA	NA	NA	NA
Naphthalene	6,000	<11	<11	<11	<11	<11	<11						
2-Methylnaphthalene	3,000	<11	<11	<11	<11	<11	<11						
Phenanthrene	50	<11	<11	<11	<11	<11	<11						
Metals (ug/L)													
Aluminum	NS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	400	NA	NA	NA	NA	NA	NA						
Barium	30,000	NA	NA	NA	NA	NA	NA						
Cadmium	10	NA	NA	NA	NA	NA	NA						
Calcium	NS	NA	NA	NA	NA	NA	NA						
Chromium	2,000	NA	NA	NA	NA	NA	NA						
Copper	NS	NA	NA	NA	NA	NA	NA						
Iron	NS	NA	NA	NA	NA	NA	NA						
Lead	30	<1.0	<2.0	<1.0	11.9	<1.0	<1.0						
Magnesium	NS	NA	NA	NA	NA	NA	NA						
Manganese	NS	NA	NA	NA	NA	NA	NA						
Mercury	1	NA	NA	NA	NA	NA	NA						
Silver	7	NA	NA	NA	NA	NA	NA						
Sodium	NS	NA	NA	NA	NA	NA	NA						
Zinc	900	NA	NA	NA	NA	NA	NA						

NOTES: (a) - Results are generally presented for only those analytes which were detected in one or more of the samples presented in this table.

In some cases, nondetect results are also presented as an indication of the analyses that were performed.

(b) - MCP Method 1 Standards for GW-3 groundwater (310CMR40.0974(2)); NS - No Standard.

Concentration detected exceeds Method 1 standard for GW-3 groundwater.

< - Not detected at or above laboratory reporting limits. For each sample, the number shown is the reporting limit specific to that sample. For the maximum detected concentration, the number shown is the most elevated sample-specific reporting limit for all of the samples presented. Reporting limits specified by the laboratory are equivalent to Practical Quantitation Limits, also known as Estimated Quantitation Limits (EQL). EQLs are defined in the U.S. EPA Test Methods for Evaluating Solid Waste (SW-846) as follows: "The lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the MDL. However, it may be nominally chosen within these guidelines to simplify data reporting. For many analytes, the EQL analyte concentration is the lowest non-zero standard in the calibration curve."

Note that the definition for MDL as used here can be obtained from 40 CFR Part 136, Appendix B.

J - Estimated.

NA - Not Analyzed

Table 5-3 (Page 1 of 2). Summary of Soil Analytical Results Relevant to UST-2

Parameter (a)	Method 1 S-1/GW-3 Standard (b)	Maximum Detected Concentration	Location of Maximum	1992 Excavation					1994 Site Investigation					
				UST-2N	UST-2E	UST-2S	UST-2W	UST-2B	SB-9 (0-2)	SB-9 (15-15.9)(15-20)	SB-10 (8.5-10.5)(6-10.5)	SB-10 (15-17)	SB-11 (4-6)(4-8)	SB-11 (8-10)
TPH (mg/Kg)	800	1,100	UST-2N	1,100	<30	70	<30	<30	221	36.1	33.1	35.1	31.4	14.7
VOCs (mg/Kg)				NA	NA	NA	NA	NA						
Benzene	40	<0.006							<0.001	<0.001	<0.001	<0.0011	<0.0011	<0.0011
Toluene	500	<0.006							<0.001	<0.001	<0.001	<0.0011	<0.0011	<0.0011
Ethylbenzene	500	<0.006							<0.001	<0.001	<0.001	<0.0011	<0.0011	<0.0011
Total xylenes	500	<0.006							<0.001	<0.001	<0.001	<0.0011	<0.0011	<0.0011
2-Butanone	40	0.002	SB-101						NA	NA	NA	NA	NA	NA
Chlorinated VOCs (mg/Kg)				NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,1-Dichloroethene	2	0.002	SB-100											
1,1-Dichloroethane	100	0.002	SB-100											
SVOCs (mg/Kg)				NA	NA	NA	NA	NA						
Naphthalene	100	<0.38							<0.37	<0.36	<0.36	<0.36	<0.38	<0.37
2-Methylnaphthalene	500	<0.38							<0.37	<0.36	<0.36	<0.36	<0.38	<0.37
Phenanthrene	100	0.42	SB-12						<0.37	<0.36	<0.36	<0.36	<0.38	<0.37

NOTES:

(a) - Results are generally presented for only those analytes which were detected in one or more of the samples presented in this table.

In some cases, nondetect results are also presented as an indication of the analyses that were performed.

(b) - MCP Method 1 Soil Standards for S-1 soil and GW-3 groundwater (310CMR40.0975(6)).

(0-2)(2-4) Numbers in parentheses are sample depths. Where two intervals are presented, the first applies to the VOC fraction and the second to the remaining analyses.

Concentration exceeds MCP Method 1 S-1/GW-3 Standard.

< - Not detected at or above laboratory reporting limits. For each sample, the number shown is the reporting limit specific to that sample. For the maximum detected concentration, the number shown is the most elevated sample-specific reporting limit for all of the samples presented. Reporting limits specified by the laboratory are equivalent to Practical Quantitation Limits, also known as Estimated Quantitation Limits (EQL). EQLs are defined in U.S. EPA Test Methods for Evaluating Solid Waste (SW-846) as follows: "The lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the MDL. However, it may be nominally chosen within these guidelines to simplify data reporting. For many analytes, the EQL analyte concentration is the lowest non-zero standard in the calibration curve." Note that the definition for MDL as used here can be obtained from 40 CFR Part 136, Appendix B.

NA - Not Analyzed

Table 5-3 (Page 2 of 2). Summary of Soil Analytical Results Relevant to UST-2

Parameter (a)	Method 1 S-1/GW-3 Standard (b)	1994 Site Investigation (Continued)							1996 Supplemental Investigation					
		SB-12 (0-2)	SB-12 (2-4)	SB-13 (4-6)	SB-13 (8-10)(6-10)	SB-14 (2-4)	SB-14 (8-10)(4-10)	SB-14D (8-10)(4-10)	SB-101 (9-11)	SB-101 (9-11)	SB-101 (16-18)	SB-100 (7-9)	SB-100 (22-24)	SB-100 (42-44)
TPH (mg/Kg)	800	6.0	21.3	145	57	9.8	10J	27.1J	NA	NA	NA	NA	NA	NA
VOCs (mg/Kg)														
Benzene	40	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Toluene	500	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Ethylbenzene	500	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Total xylenes	500	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
2-Butanone	40	NA	NA	NA	NA	NA	NA	NA	0.002J	<0.011	<0.011	<0.011	<0.011	<0.011
Chlorinated VOCs (mg/Kg)														
1,1-Dichloroethene	2	NA	NA	NA	NA	NA	NA	NA	<0.006	<0.006	<0.006	<0.006	0.002J	<0.006
1,1-Dichloroethane	100								<0.006	<0.006	<0.006	<0.006	0.002J	<0.006
SVOCs (mg/Kg)									NA	NA	NA	NA	NA	NA
Naphthalene	100	<0.36	<0.37	<0.36	<0.36	<0.37	<0.37	<0.36						
2-Methylnaphthalene	500	<0.36	<0.37	<0.36	<0.36	<0.37	<0.37	<0.36						
Phenanthrene	100	0.42	<0.37	<0.36	<0.36	<0.37	<0.37	<0.36						

NOTES:

(a) - Results are generally presented for only those analytes which were detected in one or more of the samples presented in this table.

In some cases, nondetect results are also presented as an indication of the analyses that were performed.

(b) - MCP Method 1 Soil Standards for S-1 soil and GW-3 groundwater (310CMR40.0975(6)).

(0-2)(2-4) Numbers in parentheses are sample depths. Where two intervals are presented, the first applies to the VOC fraction and the second to the remaining analyses.

Concentration exceeds MCP Method 1 S-1/GW-3 Standard.

< - Not detected at or above laboratory reporting limits. For each sample, the number shown is the reporting limit specific to that sample. For the maximum detected concentration, the number shown is the most elevated sample-specific reporting limit for all of the samples presented. Reporting limits specified by the laboratory are equivalent to Practical Quantitation Limits, also known as Estimated Quantitation Limits (EQL). EQLs are defined in U.S. EPA Test Methods for Evaluating Solid Waste (SW-846) as follows: "The lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the MDL. However, it may be nominally chosen within these guidelines to simplify data reporting. For many analytes, the EQL analyte concentration is the lowest non-zero standard in the calibration curve." Note that the definition for MDL as used here can be obtained from 40 CFR Part 136, Appendix B.

NA - Not Analyzed

Table 5-4 (Page 1 of 1). Summary of Groundwater Analytical Results Relevant to UST-2

Parameter (a)	Method 1 GW-3 Standard (b)	Maximum Detected Concentration	Location of Maximum	1994 Site Investigation (c)			1996 Supplemental Investigation						
				MW-7	MW-8	MW-9	MW-2 Bkgnd	MW-3	MW-7	MW-8	MW-9	MW-100	MW-101
TPH (ug/L)	20,000	<1,100		<1,100	<1,100	<1,100	NA	NA	NA	NA	NA	NA	NA
VOCs (ug/L)													
Benzene	7,000	<5.0		<1.0	<1.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Toluene	50,000	<5.0		<1.0	<1.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Ethylbenzene	4,000	<5.0		<1.0	<1.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Total xylenes	50,000	<5.0		<1.0	<1.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Methyl t-Butyl Ether	50,000	<5.0		NA	NA	NA	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Chlorinated VOCs (ug/L)													
1,1-Dichloroethene	50,000	19	MW-9	21	10	25	<5.0	<5.0	<5.0	<5.0	19	<5.0	<5.0
1,1-Dichloroethane	50,000	5	MW-9	3	<1.0	3	<5.0	0.8J	<5.0	<5.0	5	<5.0	<5.0
1,1,1-Trichloroethane	50,000	130	MW-9	46	32	54	<5.0	<5.0	<5.0	0.8J	130	<5.0	<5.0
Trichloroethene	20,000	20	MW-9	36	7	29	<5.0	<5.0	1J	0.9J	20	<5.0	<5.0
Methylene chloride	50,000	4	MW-9	2	<1.0	4	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
SVOCs (ug/L)													
Naphthalene	6,000	<11		<11	<11	<11	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	3,000	<11		<11	<11	<11							
Phenanthrene	50	<11		<11	<11	<11							

NOTES:

(a) - Results are generally presented for only those analytes which were detected in one or more of the samples presented in this table.

In some cases, nondetect results are also presented as an indication of the analyses performed.

(b) - MCP Method 1 Standards for GW-3 groundwater (310CMR40.0974(2)).

(c) - For the 1994 analyses, chlorinated VOCs were not target analytes, and concentrations presented are only approximate.

< - Not detected at or above the laboratory reporting limits. For each sample, the number shown is the reporting limit specific to that sample. For the maximum detected concentration, the number shown is the most elevated sample-specific reporting limit for all of the samples presented. Reporting limits specified by the laboratory are equivalent to Practical Quantitation Limits, also known as Estimated Quantitation Limits (EQL). EQLs are defined in U.S. EPA Test Methods for Evaluating Solid Waste (SW-846) as follows: "The lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the MDL. However, it may be nominally chosen within these guidelines to simplify data reporting. For many analytes, the EQL analyte concentration is the lowest non-zero standard in the calibration curve." Note that the definition of MDL as used here can be obtained from 40 CFR Part 136, Appendix B.

NA - Not Analyzed

J - Estimated

6.0 MIGRATION PATHWAYS

6.1 Evidence of and Potential for Contaminant Migration

Typical pathways that allow for the migration of contaminants include air, soil, groundwater and surface water.

6.1.1 Air. Contaminants at the disposal site have not been identified in air. Further, they are not anticipated to be identified in air since the soil contamination is located below the ground surface and the petroleum hydrocarbons are not expected to be highly volatile due to the time that has elapsed since the fuel oil release. In addition, areas of the disposal site are currently paved, heavily vegetated, or occupied by structures, effectively minimizing the potential for soil contaminants to migrate to air in the form of dust. Because development of the property is prohibited by a deed restriction (see Section 3.2.1), the potential future migration of soil contaminants to air is also not anticipated due to the expectation that future site features will generally remain the same as current site features (e.g., paved areas, vegetative cover and structures will remain). Therefore, air is not considered an existing or potential migration pathway for soil contaminants at the disposal site.

6.1.2 Soils. Petroleum hydrocarbons have been identified in subsurface soil in the vicinity of UST-1 and, to a very limited extent, the vicinity of UST-2. The analytical results from site investigations indicate these contaminants have not migrated to groundwater. However, based on slug testing conducted in 1994, the soil in the vicinity of the greatest area of residual contamination (UST-1) can be described as being moderately permeable, with an average demonstrated permeability of approximately 0.08 ft/day. Therefore, leaching from soil to groundwater is identified as a potential migration pathway for contaminants. During periods of heavy rainfall, precipitation will infiltrate the ground in areas that are not paved or covered by structures, which may enhance the migration of soil contaminants to groundwater. Further, existing pipelines (sewer and water) are present in soil in the areas of contamination. These

underground utilities may result in preferential pathways for the migration of soil contaminants to groundwater.

6.1.3 Groundwater. Contaminants related to the release of fuel oil were identified in groundwater in 1987 and 1991, but were not identified in groundwater during more extensive sampling in 1994 and 1996. Chlorinated VOCs have been detected in groundwater at concentrations up to 130 $\mu\text{g/L}$ in the immediate vicinity of the missile assembly and test building (MW-9). These chlorinated compounds are not believed to be associated with the fuel oil release from UST-2; they are likely associated with the historical use of various solvents, anti-corrosion products, and paints that were typically used in the missile assembly and test building operations at NIKE sites. Chlorinated VOCs were detected in other wells throughout the site at much lower concentrations (approximately 1 ppb), indicating that contamination diminishes rapidly with distance from MW-9. Although it is possible for groundwater to serve as a migration pathway to surface water through the migration of groundwater contaminants towards the groundwater seep located approximately 500 feet south of the property boundary, the low levels of contamination in MW-9 and even lower concentrations in wells downgradient from MW-9, indicate that migration would not likely result in detectable surface water concentrations.

6.1.4 Surface Water and Sediments. No sampling of surface water or sediments has been conducted. Based on the location and concentration of groundwater and subsurface soil contamination and the distance to surface water from the contaminant source, existing surface water at the disposal site is not likely to serve as a migration pathway for contaminants.

7.0 RISK CHARACTERIZATION

This risk characterization, performed in accordance with the revised MCP, is an evaluation of risks to human health, safety, public welfare, and the environment, posed by subsurface contaminants at the disposal site. This risk assessment is an evaluation of baseline conditions, remaining after removal of underground tanks in 1991 and associated contaminated soil in 1991 and 1992. Baseline conditions are those that exist or could exist at the disposal site with no additional remedial actions. Both current and potential future uses of the disposal site are considered in this evaluation of risk.

The risk characterization is primarily based on information presented in prior sections of this report. Contamination associated with the fuel oil releases and chlorinated solvents are considered. In the first subsection contaminants are reviewed (Section 7.1). The characterization proceeds by identifying potential receptors and exposure points (Section 7.2), classifying groundwater and soil (Section 7.3), describing selection of risk assessment Method 3 (Section 7.4), and introducing dose-response data and the quantitative human health risk estimation assumptions (Section 7.5). Risks to the environment (Section 7.6), to public welfare (Section 7.7), and to safety (Section 7.8) are evaluated, and a discussion of risk assessment uncertainty is provided (Section 7.9). Finally, risks to human health, welfare, safety and the environment are summarized (Section 7.10) and recommendations are presented (Section 7.11). Tables accompanying the risk characterization are compiled in Appendix D.

7.1 Hazard Identification

Descriptions of the property (including physical characteristics of the disposal site) and its history are presented in Sections 2.0 and 3.0. The extent of contamination is described in Section 5.0 and the potential for future migration is discussed in Section 6.0. Groundwater and soil contamination are evaluated separately for the area surrounding the former location of UST-1 in the vicinity of the barracks building, and the area surrounding the former location of

UST-2 by the missile assembly and test building, due to the different sources and types of contamination in these two areas.

7.1.1 Soil at UST-1. Soil in the vicinity of the barracks building (UST-1) has been analyzed for TPH, PCBs, VOCs, SVOCs, and metals. Based on the analytical results summarized in Section 5.1, detected VOCs, SVOCs, and TPH are potentially site-related. Acetone, phenol and bis(2-ethylhexyl)phthalate were each detected only once in soil samples that did not have significant amounts of other contaminants; the detection of these three compounds is not considered site-related. The following analytes have been identified as the contaminants of concern in soil in the vicinity of the barracks building (former UST-1 area):

- **Volatile Organic Compounds:** benzene, s-butylbenzene, ethylbenzene, isopropylbenzene, n-propylbenzene, p-isopropyltoluene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, and xylene(s)
- **Polycyclic Aromatic Hydrocarbons (PAHs):** acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, 2-methylnaphthalene, naphthalene, phenanthrene, and pyrene
- **Other Semi-volatile Compounds:** butylbenzylphthalate, dibenzofuran, di(n)octylphthalate, and N-nitrosodiphenylamine
- **Other Organic Analytes:** petroleum hydrocarbons

7.1.2 Groundwater at UST-1. Groundwater in the vicinity of the barracks building (UST-1) has been analyzed for TPH, VOCs, three PAHs and metals. Data from 1994 and 1996 have been selected for the risk characterization since they best represent the most recent site conditions. There is little overlap between the 1994 and 1996 analyses: the 1996 data are the only VOC data for which calibration for chlorinated compounds was conducted, while the 1994 data included additional analyses (SVOCs, TPH, lead, etc.). Among 1996 samples, trace levels of three VOCs were detected. Neither TPH, BTEX compounds, nor PAHs were

detected in any samples. Lead was present in a sample that was turbid due to poor recharge characteristics of the well, but was not detected in samples from other wells. Because lead concentrations have not been confirmed, lead has not been retained as an analyte of concern. Analytes identified as contaminants of concern in groundwater in the vicinity of the barracks building (former UST-1 area) are:

- **Volatile Organic Compounds:** 1,1-dichloroethane, 1,1,1-trichloroethane, and trichloroethene

7.1.3 Soil at UST-2. Soil in the vicinity of the missile assembly and test building (UST-2) has been analyzed for TPH, VOCs, and three SVOCs. TPH and trace levels of VOCs were detected in soil; SVOCs were not detected. Detected VOCs and TPH are potentially site-related. The following analytes have been identified as contaminants of concern in soil in the vicinity of the missile assembly and test building (former UST-2 area):

- **Volatile Organic Compounds:** 2-butanone (methyl ethyl ketone or MEK), 1,1-dichloroethane, and 1,1-dichloroethene
- **Other Organic Analytes:** petroleum hydrocarbons

7.1.4 Groundwater at UST-2. Analytical data from the 1996 groundwater sampling events (VOC analyses) best represent current site conditions in the vicinity of the missile assembly and test building. That data is the most timely, and provides the only calibrated data for analyses of chlorinated VOCs. TPH and PAHs were not analyzed in 1996, but these compounds were not detected during previous sampling events. Four VOCs were detected in 1996. These compounds are potentially site-related and have been identified as contaminants of concern in groundwater in the vicinity of the missile assembly and test building (former UST-2 area):

- **Volatile Organic Compounds:** 1,1-dichloroethane, 1,1-dichloroethene, 1,1,1-trichloroethane, and trichloroethene

Air has not been identified as being significantly affected by site contaminants, nor is it anticipated to be in the future. Surface water is not expected to be a migration pathway for site contaminants because the already low groundwater contaminant concentrations would be highly attenuated before reaching surface water bodies used by humans, and, therefore, any human exposures would be minimal.

7.2 Qualitative Exposure Assessment

The information in this section is based on information presented in earlier sections of this report, including a site inspection conducted by M&E on April 6, 1994.

7.2.1 Identification of Site Activities and Uses. The disposal site is wholly contained within a single piece of property, as described in Section 2.1. The property is currently inactive, and serves passively as part of a watershed protection area for a possible future reservoir which could be constructed north of the property. There are currently no workers employed at the property. The buildings at the property are not occupied. The property is surrounded by a chain-link barbed-wire fence, with an access gate off of U.S. Route 1. Based on observations during investigations in 1994 and 1996, there are several areas where the perimeter fence is collapsed or otherwise damaged, allowing easy unauthorized access onto the property. There are indications that such access does occur, as noted in Section 2.1.

The land north of the property is unoccupied, and is used as a watershed protection area in the same manner the property is used. There are developed residential lots east of the property, and a large undeveloped residential parcel to the south. West of the property is a vacant lot and a residential development (NUVA) which is used as a shelter for the homeless, AIDS patients, and people with damaged homes. Fourteen of the sixteen homes in the NUVA development are available as residences; the remaining two homes serve as an office and storage area (NUVA, 1994). Including NUVA, there are approximately 150 residents living within 1/2 mile of the disposal site, as estimated in Section 2.2.

According to the MADEP Priority Resources Map, the disposal site is not located within 500 feet of an Interim or MADEP-approved Wellhead Protection Area (IWPA or Zone II, respectively). The disposal site is also not within 500 feet of a municipal water supply or potentially productive aquifer, where a potentially productive aquifer is defined by the MCP as an aquifer delineated by the USGS as a high or medium yield aquifer in a location where the population density is less than 4,400 persons per square mile. Also, no sole source aquifer is located within 500 feet of the disposal site (Delaney and Maevsky, 1980). Communications with local officials indicate that residences north of the property in Topsfield are supplied with private wells. However, no private wells have been identified within 500 feet of the disposal site. Both the NUVA residential development west of the property, and the residential development east of the property, are supplied with public water (Topsfield, 1994; NUVA, 1994; Danvers, 1994).

It is expected that these uses of the property, its surroundings, and groundwater will continue or that similar uses will replace the current uses.

7.2.2 Potential Human Receptors. Persons who may be present at the disposal site or the surrounding area under current use include maintenance personnel, trespassers, waterline utility workers, and nearby residents. Visits by maintenance workers are expected to be infrequent, and to occur for purposes such as repairing the perimeter fence. Trespassing is also expected to be relatively infrequent. Utility workers are expected to have the most direct contact with subsurface soil under current use. Transport of subsurface contaminants to residential areas is not expected to be significant due to attenuation, as discussed in Section 6.0.

Site visitors are not expected to contact contaminated soil or groundwater because contaminants are well below grade level and subsurface activity is not expected, except in the case of the waterline workers. Migration of contaminants as vapor upwards to the ground surface is slow due to the small amount of residual contamination; also, high dilution is

expected once vapors reach the soil surface; therefore, concentrations in ambient air are expected to be negligible.

Local residents are not potential direct receptors of contaminants in groundwater because groundwater beneath the disposal site is not used as a source of drinking water. Although it is possible for groundwater contaminants to migrate south to the Putnamville Reservoir, the low concentration of contaminants in MW-9 and the even lower concentration in downgradient wells indicate substantial attenuation is expected prior to discharge. Based on this expected attenuation, drinking water consumers, recreational users and aquatic food chain consumers are not expected to be receptors.

There is no commercial agricultural use near the disposal site. Since no private wells have been identified near the disposal site, there is no known use of groundwater for gardening. Therefore, terrestrial food chain consumers are not expected to be receptors.

It is assumed that future land use will be similar to current land use, so that the exposure scenarios evaluated for current use will be valid for the disposal site in the foreseeable future. However, to reduce limitations on future site use, future residential use of the site is evaluated.

7.2.3 Identification of Environmental Receptors. Ecological receptors are unlikely to be exposed to contaminated soils at the disposal site because contaminants are generally located between 5 and 12 feet below the ground surface and contaminants in soil are present over a relatively small area. Ecological receptors that inhabit the wetland areas surrounding the property could be exposed to the more mobile contaminants via groundwater discharge to surface water. However, although it is possible for groundwater contaminants to migrate to the wetland areas, the low concentration of contaminants in MW-9 and the even lower concentration in downgradient wells indicate substantial attenuation is expected prior to discharge.

7.2.4 Exposure Points and Routes. Exposure points are areas where there is some potential for human or environmental receptors to come in contact with contaminated media.

Contaminants have been identified in subsurface soil and groundwater at the disposal site. The two areas of soil contamination are evaluated separately: (1) the previous location of UST-1, in the vicinity of the barracks building, and (2) the previous location of UST-2, in the vicinity of the missile assembly and test building. The groundwater in each of these two areas is also considered separately.

7.2.4.1 Soil. Most of the contaminants related to the subsurface fuel oil releases are not likely to reach the surface except in small amounts in vapor released to ambient air.

Therefore, exposures to soil contaminants would be mostly in connection with excavation work, such as repairing the active water line that traverses the disposal site. Utility work on this line or other construction activity could occur in either of the two specific areas where subsurface soil contamination was detected:

- soil in the vicinity of the barracks building (associated with UST-1); and
- soil near the missile assembly and test building (associated with UST-2).

Exposure to contaminants may occur through direct ingestion of soil and dermal absorption of contaminants in soil.

7.2.4.2 Groundwater. At some point distant from the disposal site, groundwater from the disposal site is expected to discharge to surface water. Contaminants in groundwater could discharge to surface water from each of two areas:

- groundwater from the vicinity of the barracks building (associated with UST-1); and
- groundwater from the vicinity of the missile assembly and test building (associated with UST-2).

Site contaminants could potentially impact natural resource areas in the vicinity of the disposal site through migration via groundwater. Groundwater has been observed to discharge through a groundwater seep (described in Section 2.3) into the red maple swamp and unnamed stream south of the property. Site contaminants could potentially reach these natural resource areas. However, based on the low levels of contamination in MW-9 and even lower concentrations in wells downgradient from MW-9, it is anticipated that groundwater contaminants would attenuate before reaching surface waters to the north and south of the site (Figure 3-4).

7.2.5 Exposure Point Concentrations for Soil. Exposure point concentrations are used to estimate exposure to contaminants. Exposure point concentrations are calculated based on measured concentrations that are representative of potential exposure points. Soil samples were collected in 1987, 1991, 1994, and 1996, and analyzed for various target compounds. Data are used where they are expected to be representative of current conditions, which includes data from each year.

For soil data, arithmetic average concentrations across an exposure area are appropriate for representing concentrations in soil to which a receptor would likely be exposed over a long-term exposure. Maximum concentrations are also evaluated to represent an upper bound risk level for each area and to account for any potential "hot spots". Samples used in the generation of exposure point concentrations for the barracks building/UST-1 area soil and the missile assembly and test building/UST-2 area soil are presented in Appendix D, Table D-1.

Exposure point concentrations for soil associated with UST-1 are presented in Table D-2 and the area of soil contamination is indicated in Figure 5-1. All samples from borings within the area of contamination indicated in Figure 5-1 are included in the exposure point concentrations with the exception of the shallower samples collected at SB-15 and SB-19. These two shallower samples were collected from the periphery of the contaminated soil area and were relatively clean. One sample (SB-2 at 10-12 feet) has a TPH concentration over 10 times the average of the other samples included in the overall exposure point concentrations. This



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August 23, 1996

Ms. Constance Lapite
METCALF & EDDY
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Wakefield, MA 01880-5371

Dear Ms. Lapite:

Please find enclosed the analytical results of 10 samples received at our laboratory on August 01-02, 1996. This report contains sections addressing the following information at a minimum:

- . sample summary
- . analytical methodology
- . state certifications
- . definition of data qualifiers and terminology
- . analytical results
- . chain-of-custody

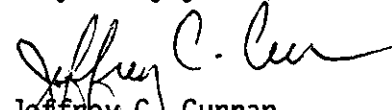
IEA Report #	7096-1471A
Project ID:	TOPSFIELD LAUNCH SITE
Purchase Order #	NLA6/WO#103035

Copies of this analytical report and supporting data are maintained in our files for a minimum of five years unless special arrangements have been made. Unless specifically indicated, all analytical testing was performed at this laboratory location and no portion of the testing was subcontracted.

We appreciate your selection of our services and welcome any questions or suggestions you may have relative to this report. Please contact your customer service representative at (203) 261-4458 for any additional information. Thank you for utilizing our services; we hope you will consider us for your future analytical needs.

I have reviewed and approved the enclosed data for final release.

Very truly yours,


Jeffrey C. Curran
Laboratory Manager

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compounds previously analyzed for. Groundwater at UST-2 was sampled in 1987, 1994, and 1996. The 1996 sampling data is used to represent exposure point concentrations because (1) the data are most recent, (2) chlorinated compounds, though detected, were not target analytes of previous rounds so the measurements of these compounds were not calibrated, (3) all analytes previously detected in groundwater at UST-2 were analyzed for in 1996, and (4) the 1996 sampling included all wells previously sampled.

7.3 Applicable Groundwater and Soil Categories

Groundwater and soil categories are defined in the MCP (310 CMR 40.0930). The categories applicable to the disposal site are summarized below.

7.3.1 Groundwater Categories. Groundwater at the disposal site is classified as GW-3, because the groundwater may eventually discharge to surface water. Site groundwater is not classified as GW-1 because it is not part of a potential drinking water supply. There is no medium or high yield aquifer, approved Zone II of a public water supply well, interim wellhead protection area, or EPA-designated Sole Source Aquifer located within one-half mile of the disposal site. Site groundwater is not classified as GW-2 because the structures at the disposal site are not occupied, and the nearest occupied structures are greater than 30 feet from the disposal site boundaries.

7.3.2 Soil Categories. Soils at the disposal site are classified primarily as S-3 with one small area of S-2. These classifications are based on the presence of children, frequency and intensity of use, presence of pavement, and soil depth (310 CMR 40.0933(4)). Children may be present at the disposal site because fencing is not adequate to prevent trespassers. However, frequency of use of the disposal site by children and all other human receptors is infrequent, in keeping with the inactive status of the property. Intensity of use is expected to be low, and relatively little direct soil contact is expected. Soil beneath the barracks building is isolated subsurface soil. The remaining contaminated soil is generally located 3 to 15 feet

below grade, which is considered potentially accessible soil (310 CMR 40.0933(4)(c)). Soil that is isolated or potentially accessible, where frequency and intensity of use are low, is classified as S-3 soil. One contaminated soil sample was collected in an unpaved area from a depth of 0 to 3 feet (accessible soil). Soil that is accessible, where frequency and intensity of use are low, is classified as S-2 soil.

Although the contaminated site soils are primarily classified as S-3 with one small area classified as S-2, a classification of S-1 is considered for purposes of characterizing risks, in order to determine whether there would be excess risks in the absence of the assumption that site use is limited.

7.4 Selection of Risk Assessment Method

Risk is characterized using MCP Method 3, which is applicable to any disposal site.

7.5 Risk of Harm to Health

Risks are quantitatively estimated in this section using MCP Method 3. Dose-response data from MADEP and EPA and exposure assumptions from MADEP (1994b, 1995b) are used to generate these estimates.

7.5.1 Applicable or Suitably Analogous Health Standards. There are no established health standards for soil or for groundwater which is not a source of drinking water. The MCP Method 1 standards are not considered applicable, since Method 3 was selected to characterize risk at the disposal site.

7.5.2 Dose-Response Data. Quantitative dose-response data available from EPA and MADEP are provided in Appendix D, Table D-6. Data are compiled from several sources which are (in order of priority): USEPA *Integrated Risk Information System* (IRIS); USEPA

Health Effects Assessment Summary Tables (HEAST); a variety of MADEP sources (*Implementation of MADEP VPH/EPH Approach* (1997), *Background Documentation* (1994b)); and Risk-Based Concentrations (RBCs) from USEPA, Region III. No data are available for two analytes detected at the site: p-isopropyltoluene and n-propylbenzene. Several other analytes have reference dose values but no slope factors for the evaluation of cancer risk. The lack of toxicity values for these analytes is addressed in the discussion of uncertainty (Section 7.9). The MADEP Relative Absorption Factors (RAFs) for chemicals of concern are compiled in Table D-7.

The toxicity of petroleum hydrocarbons depends on its constituents. For both the UST-1 and UST-2 areas, the releases were identified as diesel and/or #2 fuel oil. MADEP recommends the same fractional proportions for both diesel and #2 fuel oil (40% C9-C18 aliphatics and 60% C11-C22 aromatics), but also recommends use of VPH/EPH fractions from site data as more accurate (MADEP, 1997). Therefore, the VPH/EPH data from soil borings SB-15, SB-19, and SB-20 (Table D-2) are used as the basis for the evaluation of TPH data for both the UST-1 and UST-2 areas. The fractional proportions, based on the distribution of the averages¹, are as follows:

- 1% as C5-C8 aliphatic analytes;
- 9% as C9-C12 aliphatic analytes;
- 8% as C9-C10 aromatic analytes;
- 53% as C9-C18 aliphatic analytes;
- 6% as C19-C36 aliphatic analytes; and
- 24% as C11-C22 aromatic analytes (Table D-2).

These proportions are used along with toxicity data and RAFs recommended by MADEP (1997). MADEP recommends the use of toxicity data for n-hexane to evaluate the C5-C9

¹ The distribution of maximum concentrations is almost identical.

aliphatic fraction, n-nonane to evaluate the C9-C18 aliphatic fraction, pyrene to evaluate the C9-C22 aromatic fraction, and eicosane to evaluate the C19-C36 aliphatic fraction (Table D-6).

7.5.3 Quantitative Exposure Assessment. A worst-case screening approach is used to evaluate site soil. The soil currently at depth and categorized as S-3 and one sample categorized as S-2, are evaluated for residential exposures to children and adults (S-1 exposure scenario). This exposure scenario is unlikely under current or reasonable future use, but an evaluation based on an S-1 exposure scenario and resulting in no excess risk would reduce the level of future limitations and use complications at this disposal site.

If in the future the site contaminants currently in subsurface soil were brought to the surface of the soil and the disposal site were then used for residential development, children and adults would have an opportunity for exposure to site contaminants. Residents would have the opportunity to be exposed to contaminants in soil by ingestion and dermal contact. A resident is assumed to come into contact with the site soil for 30 years (ages 1 to 31 years). This includes the period during childhood when soil is ingested at the rate of 100 mg per day. A resident is assumed to contact soil 153 days per year, both indoors and outdoors, in this part of the country. Residents contact soil with their hands, arms, legs, and feet at the rate of 0.51 mg per cm². Also, 80 percent of the soil contacted is assumed to come from contaminated site soil. These assumptions are the basis for the MADEP residential soil standards (S-1) provided in Appendix A of *Background Documentation* (MADEP, 1994b).

The ingestion exposure is embodied in a normalized average daily soil intake rate (NADSIR) for evaluation of non-cancer risks (3.1 mg soil/kg-day) and a normalized lifetime average daily soil intake rate (NLADSIR) for the evaluation of cancer risks (0.41 mg soil/kg-day) (MADEP, 1994b). Likewise, the dermal contact exposure is embodied in a normalized average daily soil contact rate (NADSCR) for evaluation of non-cancer risks (28.5 mg soil/kg-day) and a

normalized lifetime average daily soil contact rate (NLADSCR) for the evaluation of cancer risks (7.3 mg soil/kg-day).

7.5.4 Estimated Non-Cancer and Cancer Risks. Non-cancer risks are quantified as a hazard index (HI), where a HI of less than 1 indicates that adverse non-cancer effects are unlikely. Carcinogenic risk is quantified as an excess lifetime cancer risk (ELCR), or an estimated cancer risk which is above and beyond a background lifetime risk of developing cancer, which is currently more than 30% in the United States.

Risks are calculated and presented in Appendix D. Tables D-8 and D-9 present non-cancer risk estimates for soil in the area of the barracks building (UST-1), and Tables D-10 and D-11 for soil in the area of the missile assembly and test building (UST-2). Cancer risk estimates are then presented for the area of the barracks building (Tables D-12 and D-13) and for the area of the missile assembly and test building (Tables D-14 and D-15). Risk estimates for the disposal site are summarized in Table D-16. All estimated non-cancer and cancer risks for potential future residential soil exposures were below the MADEP risk limits of 1 for non-cancer risks (HI) and 1×10^{-5} for cancer risks (ELCI) (Table D-16).

7.6 Risk of Harm to the Environment

The disposal site is either paved, vegetated with unmowed grass and brush, or occupied by structures. Therefore, environmental receptor populations will not be exposed to contaminated soil or soil gas at the disposal site. In contrast, groundwater at the disposal site may contact environmental receptors upon discharge to surface water.

7.6.1 Identification of Complete Exposure Pathways. Groundwater from the disposal site flows toward Putnamville Reservoir, which is located approximately 1,000 feet to the south of the disposal site. Between the disposal site and Putnamville Reservoir, groundwater seepage and surface water runoff support an emergent wetland that is located more than 500 feet from

the disposal site. This area is hydraulically connected to a forested wetland at the base of the slope and an intermittent stream which flows into Putnamville Reservoir. Potential environmental receptors include organisms that inhabit the emergent wetland, stream or reservoir, as well as terrestrial and semi-aquatic organisms that may utilize these wetland and aquatic habitats to some extent. Because groundwater is an ecological media of concern, an effects based screening (i.e., Stage I Environmental Screening) was conducted to determine whether or not a quantitative risk characterization would be required.

7.6.2 Effects-Based Ecological Screening. Maximum concentrations of analytes detected in specific site groundwater wells (see discussion below) were multiplied by a dilution/attenuation factor of 10 and then compared to available USEPA Ambient Water Quality Criteria (AWQC). This tenfold dilution factor is consistent with methods used by MADEP to derive GW-3 concentrations.

TPH and chlorinated VOCs are chemical classes of concern which were detected in groundwater monitoring wells located on or downgradient of the disposal site, during investigations in 1987, 1991, 1994, and 1996. Data from MW-2 and MW-3 were excluded from the screening process because they are not impacted by the disposal site. Exposure point concentrations for the Stage I screening were selected as follows:

- **TPH.** The maximum concentration reported during all site investigations was selected.
- **Chlorinated VOCs.** Data were available from the 1994 and 1996 site investigations. Among all wells, the highest concentrations were detected in MW-9. Concentrations reported in 1994 and 1996 were similar, although the 1994 data were not accurately quantified as VOCs were detected during analyses for aromatic volatile hydrocarbons. Therefore, maximum concentrations from the 1996 site investigation were selected as exposure point concentrations.

For those analytes with AWQC, the effects based screening (Appendix D, Table D-20) indicated VOCs in site groundwater do not pose a risk of harm to ecological receptors. Likewise, TPH is not expected to pose a risk of harm to ecological receptors because the diluted TPH concentration was less than the MCP Method 1 GW-3 standard.

7.7 Risk to Public Welfare

No specific potential adverse impacts to public welfare have been identified that are associated with site contamination. For instance, no nuisance conditions, restrictions of use of another person's property, or cost due to degradation of resources attributable to the site contamination has been identified. Nevertheless, MADEP has identified Upper Concentration Limits (UCLs) that must be met under a Method 3 risk characterization, in part to protect public welfare. Tables D-18 and D-19 compare site concentrations with UCLs for soil and groundwater, respectively. No soil or groundwater concentrations exceed UCLs; therefore, a state of no risk of harm to public welfare exists at the disposal site.

7.8 Risk to Safety

At specific concentrations and temperatures and in the presence of sufficient oxygen, fuel oil residues may be ignited by heat, sparks or flames. Ignitable conditions are not expected at the disposal site and there is no identified risk of ignition. Other safety risks associated with the subsurface release have not been identified. Based on known conditions, a condition of no significant risk of harm to safety exists at this disposal site.

7.9 Uncertainty Analysis

The uncertainty associated with the risk characterization is a combination of uncertainty associated with analytical data, the assumptions used in developing the exposure scenarios, and toxicity data which in turn carry uncertainty. General sources of uncertainty include:

- sampling and analytical chemistry;
- environmental fate of contaminants;
- exposure scenarios; and
- dose-response data.

7.9.1 Sampling and Analytical Uncertainty. Uncertainty originates in any sampling and measurement procedure. Uncertainties are associated with the representativeness of the sampling, as well as the analytical capabilities of the instrumentation. Soil sampling at UST-2 and groundwater sampling at both UST-1 and UST-2 were limited, so the reported values may or may not represent all existing conditions at the disposal site. However, the available data provides an indication of potential exposure point concentrations.

Compounds and parameters that the MADEP has identified as chemicals/parameters of investigatory interest for #2 fuel oil are limited to BTEX, three of the lighter-weight PAHs, and TPH (MADEP, 1991b). All of these compounds were specifically analyzed for in site samples. Other components of fuel oil may have toxic properties that have not been established to date. However, it is expected that the available analytical data includes the analytes that fairly represent the toxicity from #2 fuel oil.

Uncertainty exists because contaminants present below reporting limits cannot be quantified. The use of one-half the reporting limits for obtaining average concentrations may over-estimate or under-estimate risks. Reporting limits for a third of the UST-1 soil analytes and most of the UST-2 soil analytes were high relative to the maximum measured concentrations. Therefore, the uncertainty associated with calculating averages using one-half of reporting limits is relatively large. However, use of maximum concentrations in addition to averages is expected to provide a realistic upper bound soil risk.

7.9.2 Environmental Fate and Transport. Vapor inhalation from soil contamination is not evaluated in the risk characterization. It is expected that the evaluation of ingestion and dermal absorption are sufficiently conservative to compensate for this pathway.

There is some uncertainty associated with the characterization of risk from chlorinated compounds in groundwater, on account of the incomplete knowledge of the scope of the source of the contamination. However, based on site data, concentrations appear to be very low, relative to concentrations that would pose risks.

7.9.3 Exposure Scenarios. The use of a residential exposure scenario is expected to be highly conservative for site soil contamination currently at depth. Such a screening approach is, however, appropriate for evaluation in order to minimize future use restrictions.

7.9.4 Dose-Response Data. Uncertainties associated with the toxicological data include uncertainties associated with animal experimentation, uncertainties associated with extrapolating high experimental doses to low doses generally of concern given environmental conditions, and the uncertainties associated with extrapolating human health effects from animal data.

Dose-response data were available for non-cancer outcomes for almost all analytes and is expected to be reasonably well characterized. However, uncertainty is high where general toxicity values are used to evaluate TPH fractions.

Cancer slope factors were not available for five substituted benzenes and two phthalates. Again, use of maximum concentrations for those carcinogens for which a slope factor was available is expected to add adequate conservatism to the assessment of cancer risks at the disposal site. It is also of note, that estimated cancer risks using maximum detected concentrations were, at most, one order of magnitude below the MADEP cancer risk limit of 1×10^{-5} .

7.9.5 Overall Uncertainty. Given the variety of uncertainties associated with each step of the risk assessment process, no numerical estimate of uncertainty is made. The evaluation should therefore not be considered a determination of absolute risks, but rather a method to identify the areas of greatest concern.

7.10 Risk Summary

Based on the Method 3 risk characterization, residential exposure to site soil contamination currently at depth results in cancer and non-cancer risks below MADEP risk limits. No risk of harm to human health, welfare, safety, or the environment has been identified for the releases evaluated in this report. Any risks which might be associated with remaining buildings at the disposal site, including toxic building materials or safety hazards, are beyond the scope of this report.

7.11 Recommendations

No further action is necessary to achieve a permanent Response Action Outcome at the disposal site.

8.0 CONCLUSIONS

There are three releases at the disposal site which are addressed in this report. The first two releases pertain to the discovery of petroleum contaminated soil in the vicinity of the former location of UST-1 (behind the barracks building) and the former location of UST-2 (behind the missile assembly and test building). These two releases were discovered during the removal of the tanks in 1991. The third release consists of the discovery of chlorinated VOCs in groundwater in the vicinity of the missile assembly and test building. This release was discovered during 1995 site investigation activities. MADEP issued one NOR in 1991 for the fuel oil releases, and a second NOR in 1995 for the groundwater release. All three releases were included in a Tier II Classification submitted to MADEP on June 20, 1996. The disposal site, which is one contiguous area encompassing the three release areas, is currently tracked under RTN 3-4136.

In accordance with the MCP, an RAO can be achieved when a level of No Significant Risk exists at a disposal site. A level of No Significant Risk exists where contaminant concentrations have been reduced to background, or as established by a Method 1, 2 or 3 risk characterization. Based on investigations conducted to date and the Method 3 risk characterization included in this report, a level of No Significant Risk exists at the disposal site tracked as RTN 3-4136. No additional response actions are required to achieve a permanent RAO at the disposal site.

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APPENDIX A
BORING AND MONITORING WELL LOGS
FROM 1996 INVESTIGATIONS

Metcalf & Eddy, Inc.

ENGINEERS

GEOLOGIC LOG

PROJECT: NIKE BO-05 - TOPSFIELD					Sheet 1 of 1		Boring No. SB-15	
SITE LOCATION: Topsfield, MA			JOB NO.: 014947-0004-002			Elevation:		Total Depth 15'
DRILL CONTRACTOR: NEW HAMPSHIRE BORING			ENG/GEO: D.CLEMMER			BEGUN: 04/30/96		
DRILL RIG: MOBILE B60			DRILLER:			FINISHED: 04/30/96		
Hole Size: 4 INCH		Weather: CLOUDY, COLD, DRIZZLE				Ground Water (Depth/Elev.): 5 FEET		
Drilling Method: 2 5/8 INCH ID HSA				Drilling Fluid: NONE		Top of Rock (Depth/Elev.): NOT ENCOUNTERED		
Depth (ft)	Sample Type/No.	SPT N	Blow Counts (per 6 in) or Drilling Rate (min/ft)	Sample Recovery or REC and RQD	SAMPLE DESCRIPTION	Elev.	STRATIGRAPHIC DESCRIPTION	
0-2'	SS1		1, 3, 4, 5	10"	Organic, dark top soil		GLACIAL TILL	
2-4	SS2		3, 5, 10, 7	8"	ORGANIC SILT, fine sands, brown, dense, dry (SM)			
4-6	SS3		3, 9, 15, 12		Silty fine SAND with clay, brown tight, dense, moist (SM)			
6-8'	SS4		11, 36, 21, 28		Silty brown SAND with hard packed gray clay, wet (SM)			
10								
					Hard packed silty clay and gravel with cobbles (ML)			
15					Hard packed silt and clay with broken rock (ML)			
20								
25							Bottom of Exploration at 15 ft - auger refusal	
30								
35								
40								
SAMPLE TYPES: SS=SPLIT SPOON ST-SHELBY TUBE R = ROCK CORE			trace 0 to 10% little 10 to 20% some 20 to 35% and 35 to 50%			SPT Resistance		Approve/Date
						Cohesionless Density: 0-4 Very Loose 5-9 Loose; 10-29 Med. Dense 30-49 Dense; 50+ Very Dense		Cohesive Consistency: 0-2 Very Soft 3-4 Soft; 5-8 M/Stiff, 9-15 Stiff 16-30 V-Stiff, 31+ Hard

Metcalf & Eddy, Inc.

ENGINEERS

GEOLOGIC LOG

PROJECT: NIKE BO-05 TOPSFIELD					Sheet 1 of 1		Boring No. SB-16	
SITE LOCATION: Nike-BO-05 Topsfield, MA			JOB NO.: 014947-0004-002			Elevation:		Total Depth 19.5
DRILL CONTRACTOR: NEW HAMPSHIRE BORING					ENG/GEO:D.CLEMMER		BEGUN: 05/01/96	
DRILL RIG: MOBILE B60					DRILLER:		FINISHED: 05/01/96	
Hole Size: 4 INCH		Weather: SUNNY, DRY, WARM			Ground Water (Depth/Elev.): 13 FEET			
Drilling Method: 2 5/8 INCH ID HSA				Drilling Fluid: NONE		Top of Rock (Depth/Elev.): NOT ENCOUNTERED		
Depth (ft)	Sample Type/No.	SPT N	Blow Counts (per 6 in) or Drilling Rate (min/ft)	Sample Recovery or REC and RQD	SAMPLE DESCRIPTION	Elev.	STRATIGRAPHIC DESCRIPTION	
0-2'	SS1		2, 5, 11, 16	15"	Dark organic top soil, broken rock fragments		GLACIAL TILL	
2-4	SS2		10, 3, 3, 4	6"	Packed fine brown SAND with silt and broken rock (SM)			
4-6	SS3		2, 3, 4, 5	10"	Very fine sandy GRAVEL, wet, with silt, and broken rock (GM)			
6-8	SS4		4, 4, 9, 13		Fine GRAVEL, silt and broken rock (GM)			
8-10	SS5		4, 6, 7, 11		Silt/fine gravel with clay (ML)			
13-15	SS6		70, 16, 25, 28		Hard-packed very fine SAND and GRAVEL with silt, broken cobbles, wet (SW)			
18-20	SS7		53, 78, 73, 52		Tightly packed SILT mixed with cobbles rock, wet (ML)			
20								
25							Bottom of Exploration at 20 ft	
30								
35								
40								
SAMPLE TYPES: SS=SPLIT SPOON ST-SHELBY TUBE R = ROCK CORE			trace 0 to 10% little 10 to 20% some 20 to 35% and 35 to 50%		SPT Resistance Cohesionless Density: 0-4 Very Loose 5-9 Loose; 10-29 Med. Dense 30-49 Dense; 50+ Very Dense		Cohesive Consistency: 0-2 Very Soft 3-4 Soft; 5-8 M/Stiff, 9-15 Stiff 16-30 V-Stiff, 31+ Hard	
								Approve/Date

Metcalf & Eddy, Inc.

GEOLOGIC LOG

ENGINEERS

PROJECT: NIKE BO-05 Topsfield		Sheet 1 of 1		Boring No. SB-17	
SITE LOCATION: Topsfield, MA		JOB NO.: 14947-4-2		Elevation:	
LOCATION: N: E:		Total Depth 20'			
DRILL CONTRACTOR: New Hampshire Boring			ENG/GEO: D. CLEMMER		BEGUN: 05/02/96
DRILL RIG: CME 750			DRILLER:		FINISHED: 05/02/96
Hole Size: 8 INCH		WEATHER: OVERCAST, COOL		Ground Water (Depth/Elev.): 5 FEET	
Drilling Method: 4 1/4 INCH ID HSA			Drilling Fluid: NONE		Top of Rock (Depth/Elev.): NOT ENCOUNTERED

Depth (ft)	Sample Type/No.	SPT N	Blow Counts (per 6 in) or Drilling Rate (min/ft)	Sample Recovery or REC and RQD	SAMPLE DESCRIPTION	Elev.	STRATIGRAPHIC DESCRIPTION
0-2'	SS1		6, 5, 5, 8	16"	Dark organic topsoil/silt		GLACIAL TILL
2-4	SS2		6, 7, 7, 6	18"	Very fine silty SAND/GRAVEL, moist (GM)		
5							
5-7	SS3		11, 19, 68/5"		Silty sandy GRAVEL, some sands and broken rock (GM)		
10							
12-14	SS4		38, 83, 100/3"		Very hard packed SAND and GRAVEL, with broken rock, dry (SW)		
15							
18-20	SS5		27, 21, 33, 33		Hard packed till, broken cobbles		Bottom of Exploration at 20 ft
20							
25							
30							
35							
40							

SAMPLE TYPES: SS=SPLIT SPOON ST-SHELBY TUBE R = ROCK CORE	trace 0 to 10% little 10 to 20% some 20 to 35% and 35 to 50%	SPT Resistance		Approve/Date
		Cohesionless Density: 0-4 Very Loose 5-9 Loose; 10-29 Mod. Dense 30-49 Dense; 50+ Very Dense	Cohesive Consistency: 0-2 Very Soft 3-4 Soft; 5-8 M/Stiff, 9-15 Stiff 16-30 V-Stiff, 31+ Hard	

Metcalfe & Eddy, Inc.

ENGINEERS

GEOLOGIC LOG

PROJECT: NIKE BO-05 Topsfield					Sheet 1 of 1		Boring No. SB-18A	
SITE LOCATION: Topsfield, MA			JOB NO.: 014947-4-2		Elevation:		Total Depth 9'	
			LOCATION: N: E:					
DRILL CONTRACTOR: NEW HAMPSHIRE BORING					ENG/GEO:D.CLEMMER		BEGUN: 04/30/96	
DRILL RIG: MOBILE B60					DRILLER:		FINISHED: 04/30/96	
Hole Size: 4 INCH		WEATHER: CLOUDY, COLD, DRIZZLE				Ground Water (Depth/Elev.): Not Determined		
Drilling Method: 2 5/8 INCH ID HSA				Drilling Fluid: NONE		Top of Rock (Depth/Elev.): NOT ENCOUNTERED		
Depth (ft)	Sample Type/No.	SPT N	Blow Counts (per 6 in) or Drilling Rate (min/ft)	Sample Recovery or REC and RQD	SAMPLE DESCRIPTION	Elev.	STRATIGRAPHIC DESCRIPTION	
0-2'	SS1		5, 7, 13, 15	10"	Brown, organic, tight silty fine SAND (SM)		Top Soil	
2-4	SS2		43, 34	8"	Hard packed, silty fine brown SAND with gravel, dry (SM)			
5								
4-6	SS3		7, 14, 15, 17	6"	Hard packed, brown, medium fine sandy, GRAVEL (GM)	(ml)	GLACIAL TILL	
6-8	SS4		20, 25, 37, 33	14"	Silty moist, fine-packed SAND with clay, broken rock bits (SM)			
10							Bottom of Exploration at 9 ft - auger refusal	
15								
20								
9'								
25								
30								
35								
40								
SAMPLE TYPES:			trace 0 to 10%		SPT Resistance			
SS=SPLIT SPOON			little 10 to 20%		Cohesionless Density: 0-4 Very Loose		Cohesive Consistency: 0-2 Very Soft	
ST-SHELBY TUBE			some 20 to 35%		5-9 Loose; 10-29 Med. Dense		3-4 Soft; 5-8 M/Stiff, 9-15 Stiff	
R = ROCK CORE			and 35 to 50%		30-49 Dense; 50+ Very Dense		16-30 V-Stiff, 31+ Hard	
					Approve/Date			

Metcalf & Eddy, Inc.

ENGINEERS

GEOLOGIC LOG

PROJECT: NIKE BO-05 Topsfield					Sheet 1 of 1		Boring No. SB-19		
SITE LOCATION: Topsfield, MA			JOB NO.: 014947-4-2		Elevation:		Total Depth 19.4'		
			LOCATION: N: E:						
DRILL CONTRACTOR: New Hampshire Boring					ENG/GEO: D. CLEMMER		BEGUN: 05/01/96		
DRILL RIG: MOBILE B60					DRILLER:		FINISHED: 05/01/96		
Hole Size: 8 INCH		WEATHER: SUNNY, DRY, WARM				Ground Water (Depth/Elev.): 13 ft			
Drilling Method: 4 1/4 INCH ID HSA				Drilling Fluid: NONE		Top of Rock (Depth/Elev.): NOT ENCOUNTERED			
Depth (ft)	Sample Type/No.	SPT N	Blow Counts (per 6 in) or Drilling Rate (min/ft)	Sample Recovery or REC and RQD	SAMPLE DESCRIPTION	Elev.	STRATIGRAPHIC DESCRIPTION		
0-2'	SS1		2, 4, 5, 7	16"	Dark organic topsoil, silty, moist		GLACIAL TILL		
2-4	SS2		7, 13, 20, 25	14"	Moist tightly packed silty fine grain SAND (ML)				
5									
4-6	SS3		15, 24, 25, 23	14"	Silty very fine SAND (wet), broken rock fragments (ML)				
6-8	SS4		28, 27, 31, 30	18"	Packed silt and SAND, rock fragments (ML)				
10									
13-15'	SS5		26, 90, 115, 100/4"	20"	Packed very dense SAND and GRAVEL, silt, broken cobbles (SM)				
15									
18-19.4'	SS6		3, 117, 100/2"		Packed silty SAND and GRAVEL, broken rock (SM)		Bottom of Exploration at 19.4 ft		
20									
25									
30									
35									
40									
SAMPLE TYPES: SS=SPLIT SPOON ST-SHELBY TUBE R = ROCK CORE			trace 0 to 10% little 10 to 20% some 20 to 35% and 35 to 50%		SPT Resistance				Approve/Dat
Cohesionless Density: 0-4 Very Loose 5-9 Loose; 10-29 Med. Dense 30-49 Dense; 50+ Very Dense		Cohesive Consistency: 0-2 Very Soft 3-4 Soft; 5-8 M/Stiff, 9-15 Stiff 16-30 V-Stiff, 31+ Hard							

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ENGINEERS

GEOLOGIC LOG

PROJECT: NIKE BO-05 Topsfield					Sheet 1 of 1		Boring No. SB-20	
SITE LOCATION: Topsfield, MA			JOB NO.: 14947-4-2		Elevation:		Total Depth	
			LOCATION: N: E:					
DRILL CONTRACTOR: NEW HAMPSHIRE BORING					ENG/GEO: D. CLEMMER		BEGUN: 05/02/96	
DRILL RIG: CME 750					DRILLER:		FINISHED: 05/02/96	
Hole Size: 8 INCH		WEATHER: OVERCAST, COOL				Ground Water (Depth/Elev.): 4 Feet		
Drilling Method: 4 1/4 INCH ID HSA				Drilling Fluid: NONE		Top of Rock (Depth/Elev.): NOT ENCOUNTERED		
Depth (ft)	Sample Type/No.	SPT N	Blow Counts (per 6 in) or Drilling Rate (min/ft)	Sample Recovery or REC and RQD	SAMPLE DESCRIPTION	Elev.	STRATIGRAPHIC DESCRIPTION	
0-2'	SS1		2, 6, 6, 8	14"	Dark organic topsoil		Fill	
2-4	SS2		4, 3, 3, 8	16"	Hard packed SILT and TILL, some small broken rock (ML)			
5								
4-6	SS3		10, 12, 20, 20		Fine sandy GRAVEL with silt, with broken rock (GM)		GLACIAL TILL	
10								
10-12	SS4		18, 26, 20, 50		Till, fine sandy GRAVEL with rock bits, gray petroleum staining (GM)			
15								
15-17	SS5		24, 31, 49, 32		Till, tight fine sandy GRAVEL with broken cobbles (GM)			
18-20	SS6		38, 23, 26, 25		Fine packed SAND and GRAVEL broken cobbles (GM)			
20								
25								
30								
35								
40								
SAMPLE TYPES:			trace 0 to 10%		SPT Resistance			Approve/Date
SS=SPLIT SPOON			little 10 to 20%		Cohesionless Density: 0-4 Very Loose			Cohesive Consistency: 0-2 Very Soft 3-4 Soft; 5-8 M/Stiff, 9-15 Stiff 16-30 V-Stiff, 31+ Hard
ST-SHELBY TUBE			some 20 to 35%		5-9 Loose; 10-29 Med. Dense			
R = ROCK CORE			and 35 to 50%		30-49 Dense; 50+ Very Dense			

Metcalf & Eddy, Inc.

ENGINEERS

GEOLOGIC LOG

PROJECT : Topsfield Launch Site BO-05				SHEET 1 OF 2		BORING NO. MW-100	
SITE LOCATION: Topsfield/Danvers, Massachusetts				JOB NO.: 014947		Ground Elevation: 45.0	
LOCATION: N: E:				ENG/GEO: R. Bursaw		BEGUN : 7/31/96	
DRILL CONTRACTOR: Great Works				DRILLER: D. Dionne		FINISHED: 8/1/96	
Hole Size: 4 inch		WEATHER: overcast, humid				Ground Water (Depth/Elev.): 8.0/	
DRILLING METHOD: 5" and 4" casing				Drilling Fluid: potable water		Top of Rock (Depth/Elev.): /	
Depth	SAMPLE TYPE/NO.	PID Value (ppm)	Blow Counts (per 6 in.) or Drilling Rate (min/ft)	Sample Recovery or REC and RQD	SAMPLE DESCRIPTION	Elev. (USGS Datum)	STRATIGRAPHIC DESCRIPTION
	SS 1		7-17 25-17	19	Brown dense silty fine SAND, some to little cse-med sand, little gravel, compact, dry (SM)		TOPSOIL
	SS 2		30-32 65-52	22	Brown v dense silty fine SAND, little cse-med sand and gravel, trace roots, compact, dry (SM)		
5	SS 3		27-100 for 5"	11	same as above, cobble 4.8-5.3', auger to 6 ft		
	SS 4		21-120 for 3"	9	Brown v dense silty fine SAND, little cse-med sand and gravel, occasional cobble, compact, dry (SM)		
	SS 5		69-141 77-86	22	3" cobble at 6'9"		riser pipe
10	SS 6		23-63 45-50	21	Brown v dense silty fine SAND, little cse-med sand and gravel, occasional broken rock, compact, damp (SM)		TILL (Ablation)
	SS 7		25-120 for 4"	10	same as above, cobble at 11'10"		
	SS 8		36-105 105-120	23	same as above, top foot very loose & wet		
15	SS 9		35-82 70-120/4"	20	Brown v dense silty fine SAND, little cse-med sand and gravel, occasional cobble, firm, wet (SM)		
					boulder 16'8" to 17'4"		
	SS 10		125 for 3"	3	cobble 18' to 18.5'		
							TILL (Basal)
SAMPLE TYPES: SS=Standard Split Spoon, S3=3" Split Spoon NX=2" Rock Core				NOTES: 5" casing to 7', HW spun/wash to 25', openhole rollerbit to 45'			Approved\Date

Metcalfe & Eddy, Inc.

ENGINEERS

GEOLOGIC LOG

PROJECT: Topsfield Launch Site BO-05					SHEET 2 OF 2		BORING NO. MW-100	
SITE LOCATION: Topsfield/Danvers, Massachusetts				JOB NO.: 014947		Ground Elevation:		Total Depth 45.0
				LOCATION: N: E:				
Depth (ft.)	SAMPLE TYPE/NO.	PID Value (ppm)	Blow Counts (per 6 in.) or Drilling Rate (min/ft)	Sample Recovery or REC and RQD	SAMPLE DESCRIPTION	Elev. (USGS Datum)	STRATIGRAPHIC DESCRIPTION	
25	SS 11		47-67 129-141	10	Gray v dense silty fine SAND, some cse-med gravel, occasional cobble, trace clay, compact, wet (SM)		riser pipe	
	SS 12		17-48 59-82	11	Gray v dense SILT, some to little sand and gravel, occasional cobble, trace clay, compact, wet (ML)			
	SS 13		7-22 61-116	2	Gray v dense SILT, some to little sand and gravel, occasional cobble, trace clay, compact, wet (ML)			
	SS 14		3-37 84-131	19	Gray v dense silty SAND, some gravel, occasional cobble, compact, wet (SM)			
30	SS 15		50-67 67-118	24	Gray v dense silty SAND, some gravel, occasional cobble, compact, wet (SM)		bentonite seal	
	SS 16		30-126 130-160	15	Gray v dense SILT, some sand and gravel, occasional cobble, compact, wet (ML)			
	SS 17		29-61 72-94	24	Gray v dense silty SAND, some gravel, occasional cobble, compact, wet (SM)			
35	SS 18		26-66 80-101	24	Gray v dense silty SAND, some gravel, occasional cobble, compact, wet (SM)		TILL (Basal)	
					same as above			
40	SS 19		91-100 for 0	0	cobble 40.7' to 41.5'		well screen	
	SS 20		82-75 103-236	20	Gray v dense SILT, some sand and gravel, occasional cobble, compact, wet (ML)			
45							Bottom of Exploration @ 45 ft.	

Metcalf & Eddy, Inc.

ENGINEERS

GEOLOGIC LOG


PROJECT : Topsfield Launch Site BO-05				SHEET 1 OF 2		BORING NO. MW-101	
SITE LOCATION: Topsfield/Danvers, Massachusetts				JOB NO.: 014947		Ground Elevation: 30.0	
				LOCATION: N: E:		Total Depth (feet) 30.0	
DRILL CONTRACTOR: Great Works				ENG/GEO: R. Bursaw		BEGUN : 7/30/96	
DRILL RIG: Mobile B53				DRILLER: D. Dionne		FINISHED: 7/31/96	
Hole Size: 8 inch		WEATHER: sunny, warm, lt breeze				Ground Water (Depth/Elev.): 8.0/	
DRILLING METHOD: 4.25 inch HSA				Drilling Fluid: none		Top of Rock (Depth/Elev.): /	
Depth	SAMPLE TYPE/NO.	PID Value (ppm)	Blow Counts (per 6 in.) or Drilling Rate (min/ft)	Sample Recovery or REC and RQD	SAMPLE DESCRIPTION	Elev. (USGS Datum)	STRATIGRAPHIC DESCRIPTION
					topsoil, roots, cobbles		TOPSOIL
	SS 1		15-40 68-91	24	Brown v dense silty fine to coarse SAND AND GRAVEL, compact, dry, (SW)		
5					boulder 3.5 to 5.0 ft		
					boulder 5.0 to 7.0 ft		
	SS 2		23-38 113-80	16	Brown v dense fine sandy SILT, little med to cse sand, broken rock, angular gravel, very compact, damp, (ML)		riser pipe
10	SS 3		16-42 48-53	20	Brown v dense fine sandy SILT, some broken and weathered rock, little med to cse sand and gravel, very damp, compact, (ML)		TILL (Ablation)
	SS 4		10-25 36-49	19	Olive-brown v dense SILT, little fine-cse sand and gravel, trace clay, compact, damp, (ML)		
					cobble 13 to 13.5 ft		
15	SS 5		7-40 61-99	17	Olive-brown v dense SILT, some fine-cse sand, little gravel, occasional decomposed rock, compact, wet, (ML)		bentonite seal
	SS 6		15-65 66-78	16	Olive-brown v dense SILT, some sand and gravel, occasional decomposed or broken rock, compact, wet, (ML)		
	SS 7		90-100 for 3"	0	gravel or cobble, no recovery		
SAMPLE TYPES: SS=Standard Split Spoon, S3=3" Split Spoon NX=2" Rock Core					NOTES:		Approved\Date

Metcalf & Eddy, Inc.

ENGINEERS

GEOLOGIC LOG

PROJECT: Topsfield Launch Site BO-05					SHEET 2 OF 2		BORING NO. MW-101	
SITE LOCATION: Topsfield/Danvers, Massachusetts					JOB NO.: 014947		Ground Elevation:	
					LOCATION:		Total Depth 30.0	
N: E:								

Depth (ft.)	SAMPLE TYPE/NO	PID Value (ppm)	Blow Counts (per 6 in.) or Drilling Rate (min/ft)	Sample Recovery or REC and RQD	SAMPLE DESCRIPTION	Elev. (USGS Datum)	STRATIGRAPHIC DESCRIPTION
25	SS 8		44-55 81-94	20	Gray v dense silty fine SAND, some gravel and med-cse sand, occasional broken rock, compact, wet (SM)		 well screen TILL (Basal)
	SS 9		150 for 6"	4	same as above cobble 22.5 to 23.3 ft		
	SS 10		24-78 116-89	12	Gray v dense silty fine SAND, some gravel and med-cse sand, compact, wet, (SM)		
	SS 11		55-85 137-153	20	Gray v dense SILT, little sand and gravel, compact, wet (ML)		
	SS 12		150 for 3"	0	boulder or cobble, no recovery		
30							Bottom of Exploration @ 30 ft.
35							
40							
45							

Static Water Level: 9.78 from pie

Pg. 1 of 1

FIGURE 4-10. MONITORING WELL DEVELOPMENT FORM

MONITORING WELL DEVELOPMENT FORM

Well I.D. No.: MW-101 (SHALLOW)

Date: 6 Aug 1996

Method of Development: baiter

Logged By: R. Bursaw

Static Water Level: 9.44 from PVC

[illegible]

Total Development Time: 145 - 1340

Total Volume Purged: 5.0 gally

Comments: PID on well = 260

FIGURE 4-10. MONITORING WELL DEVELOPMENT FORM



IEA

An Aquarion Company

200 Monroe Turnpike
Monroe, Connecticut 06468

Phone 203-261-4458
Fax 203-268-5346

August 23, 1996

Ms. Constance Lapite
METCALF & EDDY
30 Harvard Mill Square
Wakefield, MA 01880-5371

Dear Ms. Lapite:

Please find enclosed the analytical results of 10 samples received at our laboratory on August 01-02, 1996. This report contains sections addressing the following information at a minimum:

- . sample summary
- . analytical methodology
- . state certifications
- . definition of data qualifiers and terminology
- . analytical results
- . chain-of-custody

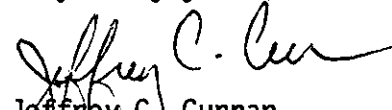
IEA Report #	7096-1471A
Project ID:	TOPSFIELD LAUNCH SITE
Purchase Order #	NLA6/WO#103035

Copies of this analytical report and supporting data are maintained in our files for a minimum of five years unless special arrangements have been made. Unless specifically indicated, all analytical testing was performed at this laboratory location and no portion of the testing was subcontracted.

We appreciate your selection of our services and welcome any questions or suggestions you may have relative to this report. Please contact your customer service representative at (203) 261-4458 for any additional information. Thank you for utilizing our services; we hope you will consider us for your future analytical needs.

I have reviewed and approved the enclosed data for final release.

Very truly yours,


Jeffrey C. Curran
Laboratory Manager

JCC

Schaumburg,
Illinois
847-705-0740

N. Billerica,
Massachusetts
508-667-1400

Whippany,
New Jersey
201-428-8181

Cary,
North Carolina
919-677-0090



printed on recycled paper

7096-1471A
METCALF & EDDY

Case Narrative

Volatile Organics - Volatile organics were determined by purge and trap GC/MS using guidance provided in Method 8260. The instrumentation used was a Tekmar Dynamic Headspace Concentrator interfaced with a Hewlett-Packard Model 5995 GC/MS/DS.

No problems were encountered.

Grain Size - Grain size was subcontracted to GeoTesting Express and analyzed by Method ASTM D422.

GEOTECHNICAL LABORATORY TEST DATA

Project : 7096-1471A
 Project No. : GTX-1150
 Boring No. : ---
 Sample No. : 100-42-44-146
 Location : ---
 Soil Description : Olive brown sandy silt
 Remarks : TF-SB-100-42-44-146

Depth : ---
 Test Date : 08/08/96
 Test Method : ASTM D422

Filename : 100
 Elevation : ---
 Tested by : jdt
 Checked by : gtt

HYDROMETER

Hydrometer ID : hl25dist
 Weight of air-dried soil = 45.12 gm
 Specific Gravity = 2.65

Hydrosopic Moisture Content :

Weight of Wet Soil = 0 gm
 Weight of Dry Soil = 0 gm
 Moisture Content = 0

Elapsed Time (min)	Reading	Temperature (deg. C)	Corrected Reading	Particle Size (mm)	Percent Finer (%)	Adjusted Particle Size
1.00	26.70	18.50	21.93	0.048	43	0.048
2.00	25.10	18.50	20.33	0.034	40	0.034
4.00	23.80	18.50	19.03	0.024	37	0.024
8.00	22.10	18.50	17.33	0.018	34	0.018
15.00	21.00	18.50	16.23	0.013	32	0.013
30.00	20.00	18.60	15.25	0.009	30	0.009
60.00	18.10	18.40	13.31	0.007	26	0.007
120.00	17.20	19.10	12.53	0.005	25	0.005
240.00	16.00	19.80	11.55	0.003	23	0.003
1368.00	14.20	18.80	9.48	0.001	19	0.001

Sieve Mesh	Sieve Openings		FINE SIEVE SET		Percent Finer (%)
	Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	
0.375"	0.374	9.51	0.00	0.00	100
#4	0.187	4.75	2.57	2.57	95
#10	0.079	2.00	3.24	5.81	89
#20	0.033	0.84	4.07	9.88	81
#40	0.017	0.42	4.07	13.95	73
#60	0.010	0.25	3.61	17.56	66
#100	0.006	0.15	3.48	21.04	59
#200	0.003	0.07	4.38	25.42	50
Pan			25.51	50.93	0

Total Dry Weight of Sample = 60.31

D85 : 1.3549 mm
 D60 : 0.1646 mm
 D50 : 0.0736 mm
 D30 : 0.0092 mm
 D15 : N/A
 D10 : N/A

Soil Classification

ASTM Group Symbol : N/A
 ASTM Group Name : N/A
 AASHTO Group Symbol : A-4(0)
 AASHTO Group Name : Silty Soils

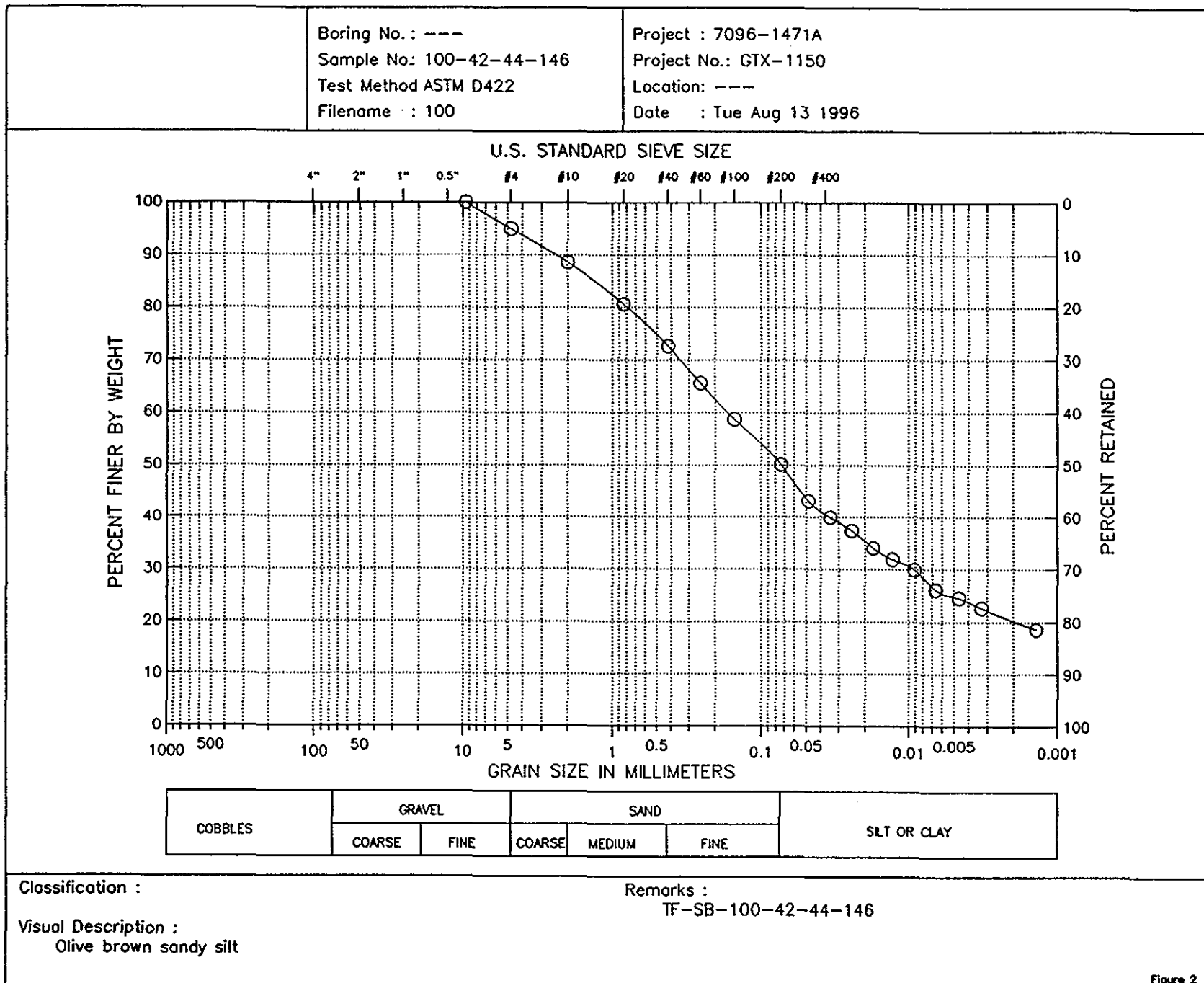


Figure 2

GEOTECHNICAL LABORATORY TEST DATA

Project : 7096-1471A
 Project No. : GTX-1150
 Boring No. : ---
 Sample No. : 101-26-28-144
 Location : ---
 Soil Description : Grayish brown sandy silt
 Remarks : TF-SB-101-26-28-144

Depth : ---
 Test Date : 08/08/96
 Test Method : ASTM D422

Filename : 101
 Elevation : ---
 Tested by : jdt
 Checked by : gtt

HYDROMETER

Hydrometer ID : h125dist
 Weight of air-dried soil = 44.54 gm
 Specific Gravity = 2.65

Hydroscopic Moisture Content :
 Weight of Wet Soil = 0 gm
 Weight of Dry Soil = 0 gm
 Moisture Content = 0

Elapsed Time (min)	Reading	Temperature (deg. C)	Corrected Reading	Particle Size (mm)	Percent Finer (%)	Adjusted Particle Size
1.00	25.50	18.50	20.73	0.048	41	0.048
2.00	23.80	18.70	19.06	0.035	38	0.035
4.00	22.20	18.70	17.46	0.025	35	0.025
8.00	21.10	18.60	16.35	0.018	33	0.018
15.00	20.10	18.60	15.35	0.013	31	0.013
30.00	19.50	18.50	14.73	0.009	29	0.009
60.00	17.20	18.50	12.43	0.007	25	0.007
120.00	16.10	19.00	11.41	0.005	23	0.005
256.00	15.00	19.90	10.60	0.003	21	0.003
1416.00	13.10	18.90	8.40	0.001	17	0.001

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Sieve Openings Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
0.375"	0.374	9.51	0.00	0.00	100
#4	0.187	4.75	2.19	2.19	96
#10	0.079	2.00	3.38	5.57	89
#20	0.033	0.84	4.59	10.16	80
#40	0.017	0.42	4.34	14.50	71
#60	0.010	0.25	4.09	18.59	63
#100	0.006	0.15	4.03	22.62	55
#200	0.003	0.07	5.28	27.90	44
Pan			22.21	50.11	0

Total Dry Weight of Sample = 59.34

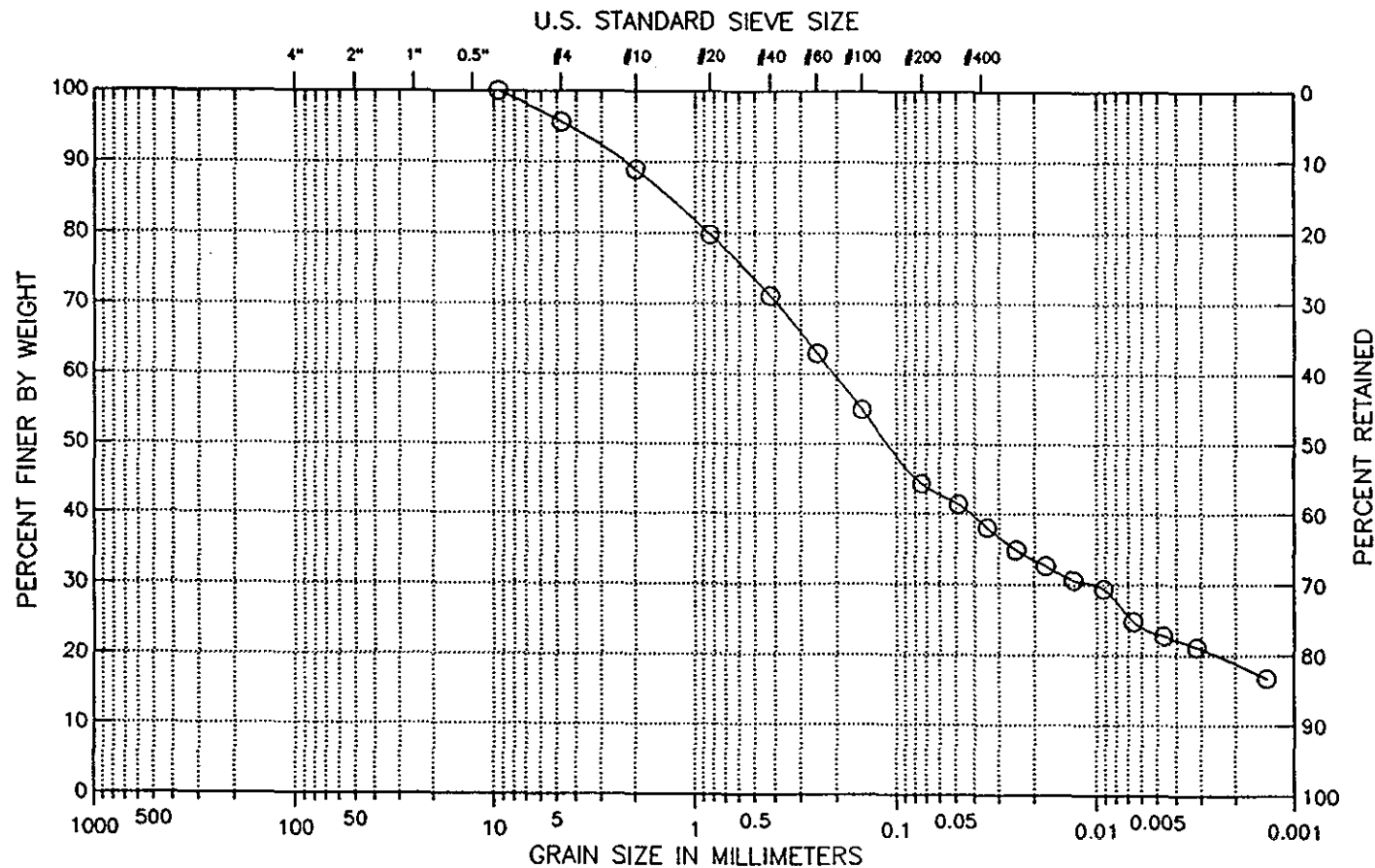
D85 : 1.3851 mm
 D60 : 0.2074 mm
 D50 : 0.1079 mm
 D30 : 0.0108 mm
 D15 : N/A
 D10 : N/A

Soil Classification

ASTM Group Symbol : N/A
 ASTM Group Name : N/A
 AASHTO Group Symbol : A-4(0)
 AASHTO Group Name : Silty Soils

Boring No. : ---
 Sample No: 101-26-28-144
 Test Method ASTM D422
 Filename : 101

Project : 7096-1471A
 Project No.: GTX-1150
 Location: ---
 Date : Tue Aug 13 1996



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Classification :

Remarks :

TF-SB-101-26-28-144

Visual Description :

Grayish brown sandy silt

APPENDIX B

1996 SLUG TEST DATA AND ANALYSIS

Slug Test Analysis - Bouwer & Rice/Hvorslev's Version: 2.5.8
 Client: USACOE Revised: 02/24/94
 Site: NIKE BO-05, Topsfield, Massachusetts Well ID: MW-100
 Test by: R. Bursaw Date: 09/04/96
 Analysis: R. Bursaw Date: 09/12/96

User Input Data Automatic A = 2.5 NA
 Aquifer Thickness 100.0 Calculati B = 0.41 NA
 Intake Length (L 12.0 (undraine C = 2.0 NA
 Well Length (LW 30.6 CHECK WATER BALANCE - Regressed v. Casing Y
 Requiv 0.1700 NA NA
 Casing Radius (RC 0.17 Estimated Porosity NA NA
 Well Radius (RW 0.375 log(Lid/RW 1.5051 NA NA
 ln(REd/RWd 2.5372 NA
 Sandpack Porosity 0.270 Shape Factor 21.8 NA
 Slug Volume 0.037
 Static Level 15.0830 Maximum Y Regressed Casing Yo
 Offset time 0.0233 Drawdown 1.98 1.92 0.41

	ft/min	cm/sec	ft/day
Bouwer & Rice - user porosity & well	8.5E-03	4.3E-03	12.22
Bouwer & Rice - estimated porosity	NA	NA	NA
Bouwer & Rice - estimated well radiu	NA	NA	NA
Hvorslev - user porosity and well ra	1.2E-02	5.9E-03	16.69
Hvorslev - estimated porosity	NA	NA	NA
Hvorslev - estimated well radius	NA	NA	NA

Regression Output: COMMENTS:
 Constant 0.717
 Std Err of Y Est 0.000
 R Squared 1.000
 No. of Observations 3
 Degrees of Freedom 1

X Coefficient(s) -2.777
 Std Err of Coef. 0.025

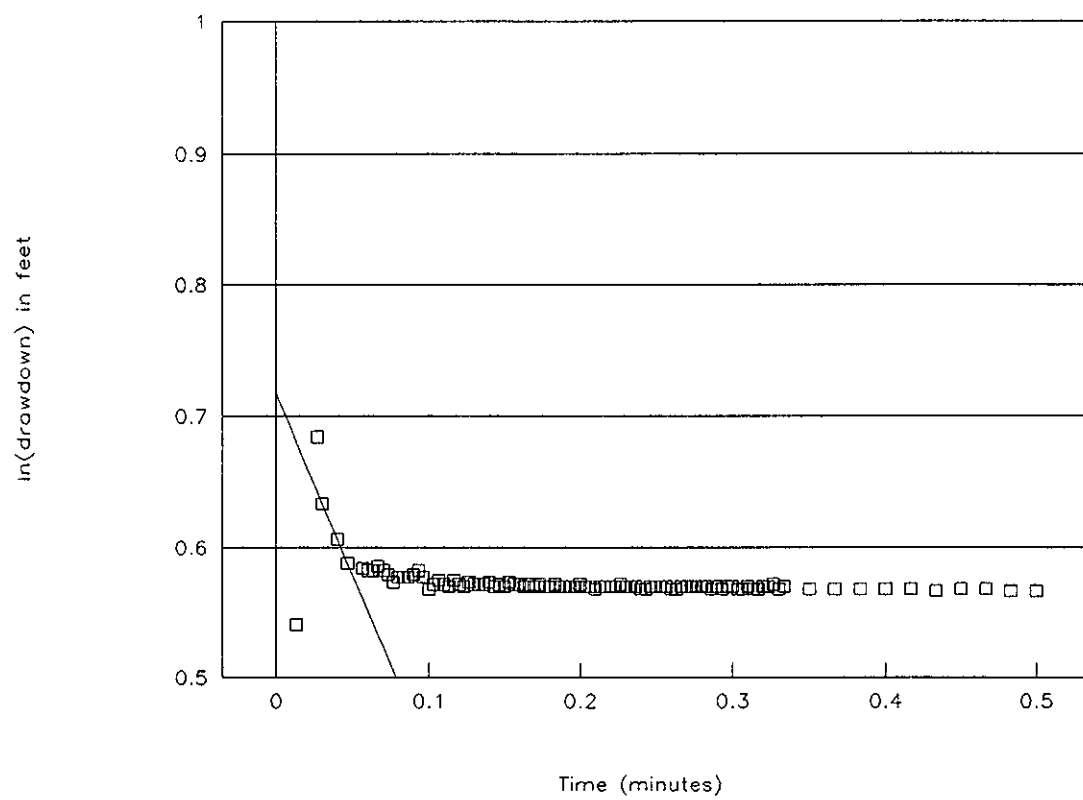
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Time (min)	level (ft)	Drawdown Y(t) ft	Indicate Regressio ln(Y) Range	Est. ln(Y)
0.0000	15.0830	0.00	NA	0.7173
0.0033	15.08	0.00	-5.81	0.7082
0.0066	15.361	0.28	-1.28	0.6990
0.01	16.377	1.29	0.26	0.6896
0.0133	16.8	1.72	0.54	0.6804
0.0166	16.437	1.35	0.30	0.6712
0.02	15.885	0.80	-0.22	0.6618
0.0233	16.655	1.57	0.45	0.6526
0.0266	17.066	1.98	0.68	0.6435
0.03	16.968	1.88	0.63 B	0.6340
0.04	16.917	1.83	0.61	0.6063
0.0466	16.883	1.80	0.59 E	0.5879
0.0566	16.876	1.79	0.58	0.5602
0.06	16.873	1.79	0.58	0.5507
0.0633	16.873	1.79	0.58	0.5416
0.0666	16.879	1.80	0.59	0.5324
0.07	16.873	1.79	0.58	0.5230
0.0733	16.867	1.78	0.58	0.5138
0.0766	16.857	1.77	0.57	0.5046
0.08	16.864	1.78	0.58	0.4952
0.0833	16.864	1.78	0.58	0.4860
0.0866	16.864	1.78	0.58	0.4769
0.09	16.867	1.78	0.58	0.4674
0.0933	16.873	1.79	0.58	0.4583
0.0966	16.864	1.78	0.58	0.4491
0.1	16.848	1.76	0.57	0.4397
0.1033	16.854	1.77	0.57	0.4305
0.1066	16.86	1.78	0.57	0.4213
0.11	16.854	1.77	0.57	0.4119
0.1133	16.851	1.77	0.57	0.4027
0.1166	16.86	1.78	0.57	0.3936
0.12	16.854	1.77	0.57	0.3841

0.1233	16.851	1.77	0.57	0.3750
0.1266	16.857	1.77	0.57	0.3658
0.13	16.854	1.77	0.57	0.3564
0.1333	16.854	1.77	0.57	0.3472
0.1366	16.854	1.77	0.57	0.3380
0.14	16.857	1.77	0.57	0.3286
0.1433	16.851	1.77	0.57	0.3194
0.1466	16.854	1.77	0.57	0.3103
0.15	16.851	1.77	0.57	0.3008
0.1533	16.857	1.77	0.57	0.2917
0.1566	16.854	1.77	0.57	0.2825
0.16	16.854	1.77	0.57	0.2731
0.1633	16.851	1.77	0.57	0.2639
0.1666	16.854	1.77	0.57	0.2547
0.17	16.851	1.77	0.57	0.2453
0.1733	16.854	1.77	0.57	0.2361
0.1766	16.851	1.77	0.57	0.2270
0.18	16.851	1.77	0.57	0.2175
0.1833	16.854	1.77	0.57	0.2084
0.1866	16.851	1.77	0.57	0.1992
0.19	16.851	1.77	0.57	0.1898
0.1933	16.851	1.77	0.57	0.1806
0.1966	16.851	1.77	0.57	0.1714
0.2	16.854	1.77	0.57	0.1620
0.2033	16.851	1.77	0.57	0.1528
0.2066	16.851	1.77	0.57	0.1437
0.21	16.848	1.76	0.57	0.1342
0.2133	16.851	1.77	0.57	0.1251
0.2166	16.851	1.77	0.57	0.1159
0.22	16.851	1.77	0.57	0.1065
0.2233	16.851	1.77	0.57	0.0973
0.2266	16.854	1.77	0.57	0.0881
0.23	16.851	1.77	0.57	0.0787
0.2333	16.851	1.77	0.57	0.0695
0.2366	16.851	1.77	0.57	0.0604
0.24	16.848	1.76	0.57	0.0509
0.2433	16.848	1.76	0.57	0.0418
0.2466	16.851	1.77	0.57	0.0326
0.25	16.851	1.77	0.57	0.0232
0.2533	16.851	1.77	0.57	0.0140
0.2566	16.851	1.77	0.57	0.0048
0.26	16.848	1.76	0.57	-0.0046
0.2633	16.848	1.76	0.57	-0.0138
0.2666	16.851	1.77	0.57	-0.0229
0.27	16.851	1.77	0.57	-0.0324
0.2733	16.851	1.77	0.57	-0.0415
0.2766	16.851	1.77	0.57	-0.0507
0.28	16.851	1.77	0.57	-0.0601
0.2833	16.851	1.77	0.57	-0.0693
0.2866	16.848	1.76	0.57	-0.0785
0.29	16.851	1.77	0.57	-0.0879
0.2933	16.848	1.76	0.57	-0.0971
0.2966	16.851	1.77	0.57	-0.1062
0.3	16.851	1.77	0.57	-0.1157
0.3033	16.848	1.76	0.57	-0.1248
0.3066	16.848	1.76	0.57	-0.1340
0.31	16.851	1.77	0.57	-0.1434
0.3133	16.848	1.76	0.57	-0.1526
0.3166	16.848	1.76	0.57	-0.1618
0.32	16.851	1.77	0.57	-0.1712
0.3233	16.851	1.77	0.57	-0.1804
0.3266	16.854	1.77	0.57	-0.1895
0.33	16.848	1.76	0.57	-0.1990
0.3333	16.851	1.77	0.57	-0.2081
0.35	16.848	1.76	0.57	-0.2545
0.3666	16.848	1.76	0.57	-0.3006
0.3833	16.848	1.76	0.57	-0.3470
0.4	16.848	1.76	0.57	-0.3933
0.4166	16.848	1.76	0.57	-0.4394
0.4333	16.845	1.76	0.57	-0.4858
0.45	16.848	1.76	0.57	-0.5322
0.4666	16.848	1.76	0.57	-0.5782
0.4833	16.845	1.76	0.57	-0.6246
0.5	16.845	1.76	0.57	-0.6710
0.5166	16.848	1.76	0.57	-0.7171
0.5333	16.845	1.76	0.57	-0.7634
0.55	16.848	1.76	0.57	-0.8098
0.5666	16.845	1.76	0.57	-0.8559
0.5833	16.848	1.76	0.57	-0.9023
0.6	16.845	1.76	0.57	-0.9486
0.6166	16.848	1.76	0.57	-0.9947
0.6333	16.845	1.76	0.57	-1.0411
0.65	16.848	1.76	0.57	-1.0875
0.6666	16.845	1.76	0.57	-1.1336
0.6833	16.845	1.76	0.57	-1.1799
0.7	16.841	1.76	0.56	-1.2263
0.7166	16.848	1.76	0.57	-1.2724
0.7333	16.848	1.76	0.57	-1.3188
0.75	16.841	1.76	0.56	-1.3651
0.7666	16.845	1.76	0.57	-1.4112
0.7833	16.845	1.76	0.57	-1.4576

0.8	16.848	1.76	0.57	-1.5040
0.8166	16.848	1.76	0.57	-1.5501
0.8333	16.845	1.76	0.57	-1.5964
0.85	16.845	1.76	0.57	-1.6428
0.8666	16.845	1.76	0.57	-1.6889
0.8833	16.848	1.76	0.57	-1.7353
0.9	16.848	1.76	0.57	-1.7816
0.9166	16.845	1.76	0.57	-1.8277
0.9333	16.845	1.76	0.57	-1.8741
0.95	16.848	1.76	0.57	-1.9205
0.9666	16.848	1.76	0.57	-1.9665
0.9833	16.845	1.76	0.57	-2.0129
1	16.841	1.76	0.56	-2.0593
1.2	16.845	1.76	0.57	-2.6146
1.4	16.845	1.76	0.57	-3.1699
1.6	16.845	1.76	0.57	-3.7252
1.8	16.841	1.76	0.56	-4.2806
2	16.845	1.76	0.57	-4.8359
2.2	16.845	1.76	0.57	-5.3912
2.4	16.841	1.76	0.56	-5.9465
2.6	16.845	1.76	0.57	-6.5019
2.8	16.841	1.76	0.56	-7.0572
3	16.845	1.76	0.57	-7.6125
3.2	16.841	1.76	0.56	-8.1678
3.4	16.841	1.76	0.56	-8.7231
3.6	16.841	1.76	0.56	-9.2785
3.8	16.841	1.76	0.56	-9.8338
4	16.845	1.76	0.57	-10.3891
4.2	16.841	1.76	0.56	-10.9444
4.4	16.841	1.76	0.56	-11.4997
4.6	16.841	1.76	0.56	-12.0551
4.8	16.841	1.76	0.56	-12.6104
5	16.838	1.76	0.56	-13.1657
5.2	16.841	1.76	0.56	-13.7210
5.4	16.838	1.76	0.56	-14.2764
5.6	16.841	1.76	0.56	-14.8317
5.8	16.838	1.76	0.56	-15.3870
6	16.838	1.76	0.56	-15.9423
6.2	16.841	1.76	0.56	-16.4976
6.4	16.838	1.76	0.56	-17.0530
6.6	16.838	1.76	0.56	-17.6083
6.8	16.841	1.76	0.56	-18.1636
7	16.841	1.76	0.56	-18.7189
7.2	16.841	1.76	0.56	-19.2742
7.4	16.841	1.76	0.56	-19.8296
7.6	16.838	1.76	0.56	-20.3849
7.8	16.838	1.76	0.56	-20.9402
8	16.841	1.76	0.56	-21.4955
8.2	16.838	1.76	0.56	-22.0509
8.4	16.838	1.76	0.56	-22.6062
8.6	16.838	1.76	0.56	-23.1615
8.8	16.838	1.76	0.56	-23.7168
9	16.838	1.76	0.56	-24.2721
9.2	16.838	1.76	0.56	-24.8275
9.4	16.838	1.76	0.56	-25.3828
9.6	16.841	1.76	0.56	-25.9381
9.8	16.841	1.76	0.56	-26.4934
10	16.835	1.75	0.56	-27.0487
11	16.838	1.76	0.56	-29.8254
12	16.838	1.76	0.56	-32.6020
13	16.838	1.76	0.56	-35.3786
14	16.838	1.76	0.56	-38.1552
15	16.838	1.76	0.56	-40.9318
16	16.838	1.76	0.56	-43.7084
17	16.838	1.76	0.56	-46.4850
18	16.838	1.76	0.56	-49.2616
19	16.835	1.75	0.56	-52.0382
20	16.835	1.75	0.56	-54.8148
21	16.835	1.75	0.56	-57.5914
22	16.835	1.75	0.56	-60.3680
23	16.838	1.76	0.56	-63.1446
24	16.832	1.75	0.56	-65.9212
25	16.835	1.75	0.56	-68.6979
26	16.832	1.75	0.56	-71.4745
27	16.835	1.75	0.56	-74.2511
28	16.832	1.75	0.56	-77.0277
29	16.835	1.75	0.56	-79.8043
30	16.829	1.75	0.56	-82.5809

REGRESSION OF MW-100 SLUG TEST DATA



Slug Test Analysis - Bouwer & Rice/Hvorslev's Version: 2.5.8
 Client: USACOE Revised: 02/24/94
 Site: NIKE BO-05, Topsfield, Massachusetts Well ID: MW-101
 Test by: R. Bursaw Date: 09/04/96
 Analysis: R. Bursaw Date: 09/12/96

User Input Data Automatic A = 2.5 NA
 Aquifer Thickness 100.0 Calculated B = 0.41 NA
 Intake Length (L) 12.0 (undrained) C = 2.0 NA
 Well Length (LW) 16.1 CHECK WATER BALANCE - Regressed v. Casing Y
 Requiv 0.1700 NA NA
 Casing Radius (RC) 0.17 Estimated Porosity NA NA
 Well Radius (RW) 0.375 log(LID/RW 1.5051 NA
 ln(RED/RWD 2.2768 NA
 Sandpack Porosity 0.270 Shape Factor 21.8 NA
 Slug Volume 0.037
 Static Level 16.0160 Maximum Y Regressed Casing Yo
 Offset time 0.0133 Drawdown 2.70 2.02 0.41

	ft/min	cm/sec	ft/day
Bouwer & Rice - user porosity & well	7.4E-03	3.8E-03	10.71
Bouwer & Rice - estimated porosity	NA	NA	NA
Bouwer & Rice - estimated well radius	NA	NA	NA
Hvorslev - user porosity and well radius	1.1E-02	5.8E-03	16.31
Hvorslev - estimated porosity	NA	NA	NA
Hvorslev - estimated well radius	NA	NA	NA

Regression Output: COMMENTS:
 Constant 0.740
 Std Err of Y Est 0.005
 R Squared 0.983
 No. of Observations 6
 Degrees of Freedom 4

X Coefficient(s) -2.714
 Std Err of Coef. 0.176

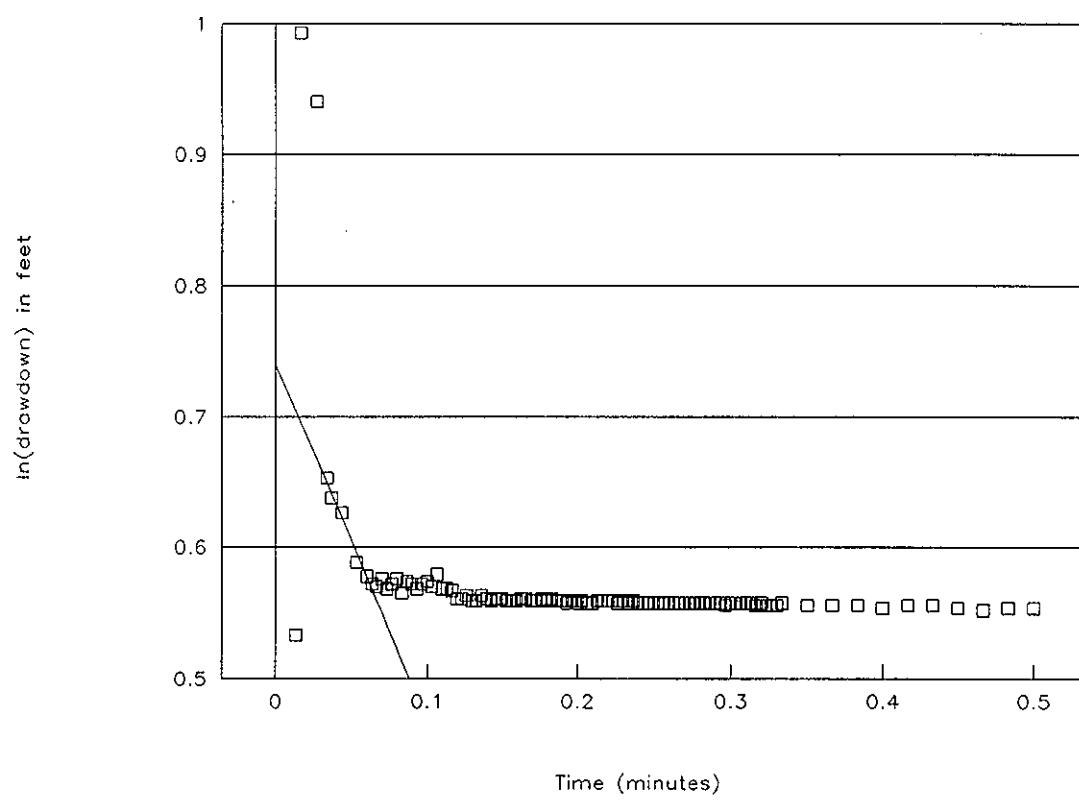
{HOME}

Time (min)	level (ft)	Drawdown Y(t) ft	Indicate Regression Range	Est. ln(Y)
0.0000	16.0160	0.00	NA	0.7402
0.0033	16.016	0.00	NA	0.7312
0.0066	16.02	0.00	-5.52	0.7223
0.01	16.023	0.01	-4.96	0.7130
0.0133	17.722	1.71	0.53	0.7041
0.0166	18.716	2.70	0.99	0.6951
0.0266	18.578	2.56	0.94	0.6680
0.0333	17.937	1.92	0.65 b	0.6498
0.0366	17.908	1.89	0.64	0.6409
0.0433	17.886	1.87	0.63	0.6227
0.0533	17.817	1.80	0.59	0.5955
0.06	17.798	1.78	0.58	0.5774
0.0633	17.788	1.77	0.57 e	0.5684
0.0666	17.785	1.77	0.57	0.5594
0.07	17.795	1.78	0.58	0.5502
0.0733	17.782	1.77	0.57	0.5413
0.0766	17.788	1.77	0.57	0.5323
0.08	17.795	1.78	0.58	0.5231
0.0833	17.776	1.76	0.57	0.5141
0.0866	17.792	1.78	0.57	0.5052
0.09	17.788	1.77	0.57	0.4959
0.0933	17.782	1.77	0.57	0.4870
0.0966	17.788	1.77	0.57	0.4780
0.1	17.792	1.78	0.57	0.4688
0.1033	17.785	1.77	0.57	0.4598
0.1066	17.801	1.79	0.58	0.4509
0.11	17.782	1.77	0.57	0.4417
0.1133	17.782	1.77	0.57	0.4327
0.1166	17.779	1.76	0.57	0.4238
0.12	17.769	1.75	0.56	0.4145
0.1233	17.769	1.75	0.56	0.4056
0.1266	17.773	1.76	0.56	0.3966

0.13	17.766	1.75	0.56	0.3874
0.1333	17.766	1.75	0.56	0.3784
0.1366	17.773	1.76	0.56	0.3695
0.14	17.769	1.75	0.56	0.3603
0.1433	17.766	1.75	0.56	0.3513
0.1466	17.769	1.75	0.56	0.3423
0.15	17.769	1.75	0.56	0.3331
0.1533	17.766	1.75	0.56	0.3242
0.1566	17.766	1.75	0.56	0.3152
0.16	17.766	1.75	0.56	0.3060
0.1633	17.769	1.75	0.56	0.2970
0.1666	17.769	1.75	0.56	0.2881
0.17	17.766	1.75	0.56	0.2788
0.1733	17.766	1.75	0.56	0.2699
0.1766	17.769	1.75	0.56	0.2609
0.18	17.766	1.75	0.56	0.2517
0.1833	17.769	1.75	0.56	0.2427
0.1866	17.766	1.75	0.56	0.2338
0.19	17.766	1.75	0.56	0.2246
0.1933	17.763	1.75	0.56	0.2156
0.1966	17.766	1.75	0.56	0.2067
0.2	17.763	1.75	0.56	0.1974
0.2033	17.766	1.75	0.56	0.1885
0.2066	17.763	1.75	0.56	0.1795
0.21	17.763	1.75	0.56	0.1703
0.2133	17.766	1.75	0.56	0.1613
0.2166	17.766	1.75	0.56	0.1524
0.22	17.766	1.75	0.56	0.1432
0.2233	17.766	1.75	0.56	0.1342
0.2266	17.763	1.75	0.56	0.1252
0.23	17.766	1.75	0.56	0.1160
0.2333	17.763	1.75	0.56	0.1071
0.2366	17.766	1.75	0.56	0.0981
0.24	17.763	1.75	0.56	0.0889
0.2433	17.763	1.75	0.56	0.0799
0.2466	17.763	1.75	0.56	0.0710
0.25	17.763	1.75	0.56	0.0617
0.2533	17.763	1.75	0.56	0.0528
0.2566	17.763	1.75	0.56	0.0438
0.26	17.763	1.75	0.56	0.0346
0.2633	17.763	1.75	0.56	0.0256
0.2666	17.763	1.75	0.56	0.0167
0.27	17.763	1.75	0.56	0.0075
0.2733	17.763	1.75	0.56	-0.0015
0.2766	17.763	1.75	0.56	-0.0104
0.28	17.763	1.75	0.56	-0.0197
0.2833	17.763	1.75	0.56	-0.0286
0.2866	17.763	1.75	0.56	-0.0376
0.29	17.763	1.75	0.56	-0.0468
0.2933	17.763	1.75	0.56	-0.0558
0.2966	17.76	1.74	0.56	-0.0647
0.3	17.763	1.75	0.56	-0.0739
0.3033	17.763	1.75	0.56	-0.0829
0.3066	17.763	1.75	0.56	-0.0919
0.31	17.763	1.75	0.56	-0.1011
0.3133	17.763	1.75	0.56	-0.1100
0.3166	17.76	1.74	0.56	-0.1190
0.32	17.763	1.75	0.56	-0.1282
0.3233	17.76	1.74	0.56	-0.1372
0.3266	17.76	1.74	0.56	-0.1461
0.33	17.76	1.74	0.56	-0.1554
0.3333	17.763	1.75	0.56	-0.1643
0.35	17.76	1.74	0.56	-0.2096
0.3666	17.76	1.74	0.56	-0.2547
0.3833	17.76	1.74	0.56	-0.3000
0.4	17.757	1.74	0.55	-0.3453
0.4166	17.76	1.74	0.56	-0.3904
0.4333	17.76	1.74	0.56	-0.4357
0.45	17.757	1.74	0.55	-0.4810
0.4666	17.754	1.74	0.55	-0.5261
0.4833	17.757	1.74	0.55	-0.5714
0.5	17.757	1.74	0.55	-0.6167
0.5166	17.757	1.74	0.55	-0.6617
0.5333	17.757	1.74	0.55	-0.7071
0.55	17.757	1.74	0.55	-0.7524
0.5666	17.757	1.74	0.55	-0.7974
0.5833	17.757	1.74	0.55	-0.8428
0.6	17.757	1.74	0.55	-0.8881
0.6166	17.754	1.74	0.55	-0.9331
0.6333	17.757	1.74	0.55	-0.9784
0.65	17.757	1.74	0.55	-1.0238
0.6666	17.757	1.74	0.55	-1.0688
0.6833	17.754	1.74	0.55	-1.1141
0.7	17.754	1.74	0.55	-1.1594
0.7166	17.754	1.74	0.55	-1.2045
0.7333	17.754	1.74	0.55	-1.2498
0.75	17.754	1.74	0.55	-1.2951
0.7666	17.751	1.74	0.55	-1.3402
0.7833	17.751	1.74	0.55	-1.3855
0.8	17.754	1.74	0.55	-1.4308
0.8166	17.754	1.74	0.55	-1.4759

0.8333	17.754	1.74	0.55	-1.5212
0.85	17.754	1.74	0.55	-1.5665
0.8666	17.754	1.74	0.55	-1.6116
0.8833	17.751	1.74	0.55	-1.6569
0.9	17.754	1.74	0.55	-1.7022
0.9166	17.754	1.74	0.55	-1.7472
0.9333	17.754	1.74	0.55	-1.7926
0.95	17.751	1.74	0.55	-1.8379
0.9666	17.754	1.74	0.55	-1.8829
0.9833	17.754	1.74	0.55	-1.9283
1	17.751	1.74	0.55	-1.9736
1.2	17.751	1.74	0.55	-2.5163
1.4	17.751	1.74	0.55	-3.0591
1.6	17.747	1.73	0.55	-3.6018
1.8	17.751	1.74	0.55	-4.1446
2	17.747	1.73	0.55	-4.6873
2.2	17.744	1.73	0.55	-5.2301
2.4	17.747	1.73	0.55	-5.7728
2.6	17.747	1.73	0.55	-6.3156
2.8	17.747	1.73	0.55	-6.8583
3	17.747	1.73	0.55	-7.4011
3.2	17.747	1.73	0.55	-7.9438
3.4	17.744	1.73	0.55	-8.4866
3.6	17.744	1.73	0.55	-9.0293
3.8	17.747	1.73	0.55	-9.5721
4	17.744	1.73	0.55	-10.1148
4.2	17.744	1.73	0.55	-10.6576
4.4	17.744	1.73	0.55	-11.2003
4.6	17.747	1.73	0.55	-11.7431
4.8	17.747	1.73	0.55	-12.2858
5	17.744	1.73	0.55	-12.8286
5.2	17.744	1.73	0.55	-13.3713
5.4	17.744	1.73	0.55	-13.9141
5.6	17.744	1.73	0.55	-14.4568
5.8	17.744	1.73	0.55	-14.9996
6	17.744	1.73	0.55	-15.5423
6.2	17.741	1.73	0.55	-16.0851
6.4	17.744	1.73	0.55	-16.6278
6.6	17.744	1.73	0.55	-17.1706
6.8	17.744	1.73	0.55	-17.7133
7	17.744	1.73	0.55	-18.2561
7.2	17.744	1.73	0.55	-18.7988
7.4	17.741	1.73	0.55	-19.3416
7.6	17.744	1.73	0.55	-19.8843
7.8	17.744	1.73	0.55	-20.4271
8	17.744	1.73	0.55	-20.9698
8.2	17.741	1.73	0.55	-21.5126
8.4	17.744	1.73	0.55	-22.0553
8.6	17.744	1.73	0.55	-22.5981
8.8	17.741	1.73	0.55	-23.1408
9	17.744	1.73	0.55	-23.6836
9.2	17.744	1.73	0.55	-24.2263
9.4	17.741	1.73	0.55	-24.7691
9.6	17.744	1.73	0.55	-25.3118
9.8	17.741	1.73	0.55	-25.8546
10	17.744	1.73	0.55	-26.3973
11	17.741	1.73	0.55	-29.1111
12	17.741	1.73	0.55	-31.8248
13	17.744	1.73	0.55	-34.5386
14	17.744	1.73	0.55	-37.2523
15	17.741	1.73	0.55	-39.9661
16	17.741	1.73	0.55	-42.6798
17	17.741	1.73	0.55	-45.3936
18	17.744	1.73	0.55	-48.1073
19	17.741	1.73	0.55	-50.8211
20	17.741	1.73	0.55	-53.5348
21	17.741	1.73	0.55	-56.2486
22	17.741	1.73	0.55	-58.9623
23	17.738	1.72	0.54	-61.6761
24	17.741	1.73	0.55	-64.3898
25	17.738	1.72	0.54	-67.1036
26	17.738	1.72	0.54	-69.8173
27	17.738	1.72	0.54	-72.5311
28	17.738	1.72	0.54	-75.2448
29	17.738	1.72	0.54	-77.9586
30	17.738	1.72	0.54	-80.6723
31	17.738	1.72	0.54	-83.3861
32	17.738	1.72	0.54	-86.0998
33	17.738	1.72	0.54	-88.8136
34	17.738	1.72	0.54	-91.5273
35	17.735	1.72	0.54	-94.2411
36	17.735	1.72	0.54	-96.9548
37	17.735	1.72	0.54	-99.6686

REGRESSION OF MW-101 SLUG TEST DATA



APPENDIX C

**MONITORING WELL SAMPLING WORKSHEETS
1996 SITE INVESTIGATION STUDY**

MONITORING WELL SAMPLING WORKSHEET

Job Name: TOPSFIELD Job No.: 014947 Samplers: R. BURSAWWell ID: MW-1 Date Sampled: 22 May 1996 Time: 1340 1550
Start EndWell Diameter: 2 inch inches + 12 = _____ (d) ft. Well secured upon arrival? YNDepth of well from T.O.C. _____ ft. Depth of water from T.O. PVC 7.09 7.074
tubingDepth to water from T.O.C. _____ ft. Depth of well from T.O. PVC 17.66

Feet of standing water _____ (h) ft. Standing water (gal.) = _____

Standing Water Volume: $\pi((d)^2 + 4) (h)$
 $3.14 ((\text{in})^2 + 4) (\text{ft}) \times 7.48 \text{ gal/ft}^3 = \text{gals.}$

PID Readings (ppm)

Breathing 0.0Well 0.0Purging method peristalticPurge: Time Start 1350 End 1550

	Time	Water Level	pH	Eh	MS/cm Conductivity	Temp (C)	mg/l DO	Turbidity
Initial Reading	<u>1:55</u>	<u>7.8</u>	<u>6.75</u>	<u>-</u>	<u>0.188</u>	<u>11.7</u>	<u>4.41</u>	<u>4</u>
Final Reading	<u>1548</u>	<u>8.73</u>	<u>6.72</u>	<u>-</u>	<u>0.181</u>	<u>11.0</u>	<u>3.96</u>	<u>0</u>

Sample Collection: Time Start 1543 End 1545Sample method peristaltic Bailer Type NASamples preserved? HCL < 2 pH
Sample Characteristics (circle all applicable)Describe odor: none sulfide fishy musty petroleumDescribe color: colorless black brown orange red

Describe appearance: turbid silty sand clay floaters sheen

clear multiphased foaming slimy algaeOrganic Layer? none Length? _____ Floating or Sinking or Other? _____Comments 3 well screen volumes \approx 5 gals.
tubing set at 12.5

Refer to page _____ of the corresponding field log book.

MONITORING WELL SAMPLING WORKSHEET

Job Name: TOP FIELD Job No.: 014947- Samplers: B. BURMAN / C. LAPITEWell ID: MW-2 Date Sampled: 21 Mar. 1996 Time: 0800 1240
Start EndWell Diameter: 2 inch inches + 12 = _____ (d) ft. Well secured upon arrival? YN

Depth of well from T.O.C. _____ ft.

Depth of water from T.O. PVC 9.24

Depth to water from T.O.C. _____ ft.

Depth of well from T.O. PVC 13.25

Feet of standing water _____ (h) ft.

Standing water (gal.) = ~1.0 gal

$$\text{Standing Water Volume} = \pi((d)^2 + 4)(h) \\ 3.14((2)^2 + 4)(1) \times 7.48 \text{ gal/ft}^3 = \text{_____ gal.}$$

PID Readings (ppm)

Breathing _____

Well _____

Depth to screen = 3.25 ft
Depth to midpt = 8.25Purging method peristaltic pumpPurge: Time Start 0823 End 12171 well screen volume = 5.6 gal
(saturated) 1.0 gal

	Time	Water Level	pH	Eh	Conductivity	Temp (C)	DO	Turbidity	Flow
Initial Reading	<u>840</u>	<u>9.53</u>	<u>5.54</u>	<u>—</u>	<u>0.092</u>	<u>14.9</u>	<u>7.98</u>	<u>22</u>	<u>134 ml/min</u>
Final Reading	<u>1230</u>	<u>11.24</u>	<u>5.60</u>	<u>—</u>	<u>0.075</u>	<u>17.1</u>	<u>4.42</u>	<u>3</u>	

Sample Collection: Time Start 1230 837 amEnd 1236Sample method peristaltic Pump

Bailer Type _____

Samples preserved? Yes / HCl pH < 2

Sample Characteristics (circle all applicable)

Describe odor: none sulfide fishy musty petroleumDescribe color: colorless black brown orange red

Describe appearance: turbid silty sand clay floaters sheen

clear multiphased foaming slimy algaeOrganic Layer? none Length? _____ Floating or Sinking or Other? _____

Comments Water is well below top of screen. Purged as slowly as possible. 15 feet deep well

10 feet screen

5 feet to top of screen

Teflon tubing down 13 feet from top of PVC

Refer to page _____ of the corresponding field log book.

15 ft

3.25 ft to top of screen

+ 5

8.25 ft to mid of screen

13.258.25 ft

2.3

2.3

2.0

10.1

0.6

Rev.
Oct-94

MONITORING WELL SAMPLING WORKSHEET

Job Name: Topsfield Job No.: 014947 Samplers: R. BURSAWWell ID: MW-3 Date Sampled: 21 MAY 1996 Time: 9:00 11:00
Start EndWell Diameter: _____ inches + 12 = _____ (d) ft. Well secured upon arrival? ☒ Y ☐ NDepth of well from T.O.C. _____ ft. Depth of water from T.O. PVC 13.75 ^{13.7 w tube}Depth to water from T.O.C. _____ ft. Depth of well from T.O. PVC 27.14

Feet of standing water _____ (h) ft. Standing water (gal.) = _____

Standing Water Volume $\pi((d)^2 \div 4) (h)$
 $3.14 ((\text{in})^2 \div 4) (\text{ft}) \times 7.48 \text{ gal/ft}^3 = \text{gal.}$

PID Readings (ppm)

Breathing 0.0Well 24.7Purging method peristalticPurge: Time Start 9:03 End 10:55

	Time	Water Level	pH	Eh	Conductivity	Temp (C)	DO	Turbidity
Initial Reading	<u>9:00</u>	<u>13.7</u>	<u>6.10</u>		<u>0.340</u>	<u>17.4</u>	<u>2.58</u>	<u>852</u>
Final Reading	<u>10:55</u>	<u>15.51</u>	<u>6.3</u>		<u>0.320</u>	<u>19.0</u>	<u>2.5</u>	<u>0</u>

Sample Collection: Time Start 10:40 End 10:45Sample method peristaltic Bailer Type _____Samples preserved? yes, HCL

Sample Characteristics (circle all applicable)

Describe odor: none sulfide fishy musty petroleum _____Describe color: colorless black brown orange red _____

Describe appearance: turbid silty sand clay floaters sheen _____

clear multiphased foaming slimy algae _____Organic Layer? no Length? _____ Floating or Sinking or Other? _____Comments 3 well screen holes = 14.54 gals.Pump running erratically; cannot be lowered to more than 260 mlScreen 17-27 water 11

Refer to page _____ of the corresponding field log book.

MONITORING WELL SAMPLING WORKSHEET

Job Name: Tapfield Job No.: 014947 Samplers: C KayateWell ID: MW-04 Date Sampled: 5/22/96 Time: 0830 1245
Start EndWell Diameter: 2 inches + 12 = _____ (d) ft. Well secured upon arrival? YNDepth of well from T.O.C. _____ ft. Depth of water from T.O. PVC 7.96

Depth to water from T.O.C. _____ ft. Depth of well from T.O. PVC _____

Feet of standing water _____ (h) ft. Standing water (gal.) = _____

Standing Water Volume: $13((d)^2 + 4)(h)$
 $3.14((\text{---})^2 + 4)(\text{---}) \times 7.48 \text{ gal/ft}^3 = \text{---} \text{ gals.}$

PID Readings (ppm)

Breathing 10 Purge Water 28 ppm
Well 7.4Purging method Perisaltic Purge: Time Start 0910 End 1232

	Time	Water Level	pH	Eh	Conductivity	Temp (C)	mg/l DO	Turbidity	mV/min Flow
Initial Reading	<u>0914</u>	<u>8.62</u>	<u>7.28</u>	<u>—</u>	<u>0.472</u>	<u>13.3</u>	<u>5.36</u>	<u>0</u>	<u>120</u>
Final Reading	<u>1237</u>	<u>11.47</u>	<u>6.93</u>	<u>—</u>	<u>0.482</u>	<u>12.3</u>	<u>2.49</u>	<u>0</u>	

Sample Collection: Time Start 1235 End 1238Sample method Perisaltic Bailer Type _____Samples preserved? yes

Sample Characteristics (circle all applicable)

Describe odor: none sulfide fishy musty petroleum _____Describe color: colorless black brown orange red _____

Describe appearance: turbid silty sand clay floaters sheen _____

clear multiphased foaming slimy algae Some rustOrganic Layer? none Length? _____ Floating or Sinking or Other? _____Comments Well Depth = 24.0 ft + st. jump (2.5') = 26.5 ftScreen = 12 + st. jump to 22 + st. jump 19.5 - 24.5 screenTubing = 17 + st. jump = 19.5 ft tubing2/3 in. - can draw to 12.3 feet from Top PVCvery Rusty Casing; PVC Cap intact 14.5

Refer to page _____ of the corresponding field log book.

7.9
 $6.6 \text{ ft} \times \frac{2}{3} = 13.2 \text{ Rev.}$
3 3 Oct 94
 $4.4 \text{ ft} + 7.9 = 12.3 \text{ ft}$

MONITORING WELL SAMPLING WORKSHEET (ADDITIONAL PAGES)

Job Name: Topfield Job No.: 014947 Samplers: ChapleWell ID: MU-04 Date Sampled: 5/22/96

Time	Water Level	pH	Eh	Conductivity	Temp (C)	DO	Turbidity
0908	7.91	after Tubing inserted					
0917	9.27	7.32	—	0.485	13.6	3.14	5
0920	emptied	no. 5 gal					
0923	9.99	7.32	—	0.527	12.3	5.00 ¹	Ø
0926	10.56	7.31	—	0.528	12.8	2.53	Ø
0928	slowed flow rate to				100 ml/min		
0934	11.16	7.30	—	0.584	13.2	3.72	Ø
0937	11.48	7.25	—	0.499	13.3	2.57	Ø
0938	approx 1 gal removed; slowed flow to				80 ml/min		
0941	11.73	7.23	—	0.502	13.6	2.58	Ø
	Pump shut down had to increase flow to				120 ml/min		
0944	12.03	7.21	—	0.524	12.9	2.72	Ø
0947	12.24	7.18	—	0.503	12.5	3.41	Ø
0948	Pump shut down — well allowed to recharge						
1045	water level recharged —				94.2 feet		
1049							
1046	10.38	7.10	—	0.473	16.2	5.18	Ø
1053	10.74	7.09	—	0.480	14.3	2.77	Ø
1056	10.99	7.07	—	0.483	13.9	3.11	Ø
1059	11.04	7.05	—	0.482	13.8	2.37	Ø
1102	11.50	7.02	—	0.482	13.6	2.47	Ø
1105	11.71	7.01	—	0.483	13.6	2.35	Ø
1108	11.94	6.99	—	0.485	13.5	2.36	Ø
1111	12.02	6.97	—	0.482	13.6	2.95	Ø
1112	Pump shut down, well to recharge; 1 gal removed						
1216	9.28	Pump turned on					
1219	9.78	7.06	—	0.479	18.3	3.36 5.12	54
1226	10.70	7.03	—	0.475	13.5	3.30	2
1229	10.93	6.97	—	0.475	13.0	2.77	Ø
1232	11.15	6.95	—	0.476	12.8	1.92	Ø

Flow:
ml/min
160

SAMPLING

MONITORING WELL SAMPLING WORKSHEET

Job Name: TOPSFIELD NIKE Job No.: 014947 Samplers: R. BURSAW

Well ID: MW-5 Date Sampled: 23 May '96 Time: 9:50 1311

Well Diameter: 2 - inch inches + 12 = (d) ft. Well secured upon arrival? ☒ Y/N

Depth of well from T.O.C. _____ ft. Depth of water from T.O. PVC w/out tubing _____ tubing

Depth to water from T.O.C.	ft.	Depth of well from T.O. PVC	18.0	Well screen 8-18
----------------------------	-----	-----------------------------	------	---------------------

Feet of standing water _____ (n) ft. Standing water (gal.) = _____

Standing Water Volume: $\pi ((R)^2 + 4) (h)$
 $3.14 ((\quad R)^2 + 4) (\quad R) \times 7.48 \text{ gal/ft}^3 = \quad \text{gals.}$

PID Readings (ppm)

Breathing 0.0

Well 12.5

Purging method peristaltic pump Purge: Time Start 10:05 End 13:05

	<u>Time</u>	<u>Water Level</u>	<u>pH</u>	<u>Eh</u>	<u>Conductivity</u>	<u>Temp (C)</u>	<u>DO</u>	<u>Turbidity</u>
Initial Reading	<u>10:08</u>	<u>7.43</u>	<u>6.94</u>	<u>—</u>	<u>0.278</u>	<u>13.4</u>	<u>5.42</u>	<u>0</u>
Final Reading	<u>1311</u>	<u>8.83</u>	<u>6.82</u>	<u>—</u>	<u>0.186</u>	<u>11.9</u>	<u>5.59</u>	<u>0</u>

Sample Collection: Time Start 1307 End 1310

Sample method peristaltic (low flow) Bailer Type NA

Samples preserved? HCL to pH < 2

Describe odor: none sulfide fishy musty petroleum

Describe color: colorless black brown orange red

Describe appearance: turbid silty sand clay floaters sheen

clear multiphased foaming slimy algae

Organic Layer? none Length? — Floating or Sinking or Other? —

Comments 3 well screen volumes = ~5 gals.

tubing set @ 13 ft

* hariba dropped in overflow bucket. DO and turbidity sensors may not have been

reading properly before this reading

Refer to page _____ of the corresponding field log book.

MONITORING WELL SAMPLING WORKSHEET (ADDITIONAL PAGES)

Job Name: TOPSFIELD Job No.: 014947 Samplers: R. BURSALWWell ID: MW-5 Date Sampled: 23 May 1996PUMP
RATE

Time	Water Level	pH	Eh	Conductivity	Temp (C)	mg/L DO	Turbidity
10:15	7.93						
10:20	8.06						
10:25	8.17	6.89	—	0.202	11.9	13.48	130
10:30	8.21	6.85	—	0.203	11.7	14.60	123
10:35	8.25	6.82	—	0.204	11.8	14.87	124
10:40	8.28	6.81	—	0.201	11.7	14.99	124
10:45	8.31	6.81	—	0.194	11.7	4.56	0
10:50	8.35						
10:55	8.38						
11:00	8.39						
11:05	8.42						
11:10	8.44						
11:15	8.47	6.65	—	0.190	11.6	5.11	2
11:20	8.50	6.83	—	0.187	12.0	12.27	0
11:25	8.53	6.85	—	0.188	11.6	4.62	0
11:30	8.57						
11:35	8.58	6.84	—	0.190	10.8	5.80	0
11:40	8.63	6.83	—	0.189	10.6	5.27	0
11:45	8.66	6.83	—	0.189	10.5	5.50	0
11:50	8.69	6.83	—	0.188	10.9	5.42	0
11:55	8.71	6.82	—	0.188	10.8	5.38	0
12:00	8.72	6.82	—	0.186	11.1	5.23	0
12:05	8.73	6.83	—	0.187	11.0	4.90	0
12:40	8.78						
12:45	8.80	6.84	—	0.188	12.1	11.17	0
12:50	8.81	6.83	—	0.186	12.1	5.18	0
12:55	8.82	6.82	—	0.186	11.8	5.14	0
13:00	8.83	6.82	—	0.186	11.7	4.97	0

90 ml/min

90 ml/min

100 ml/min

110 ml/min

MONITORING WELL SAMPLING WORKSHEET

Job Name: TOPSFIELD NIKE Job No.: 014947 Samplers: C. LaporteWell ID: MW-6 Date Sampled: 23 May '96 Time: 0915 1445
Start EndWell Diameter: 2" inches + 12 = (d) ft. Well secured upon arrival? (Y)Depth of well from T.O.C. ft. Depth of water from T.O. PVC 6.95Depth to water from T.O.C. ft. Depth of well from T.O. PVC 17.0 well screen 7-17Feet of standing water (h) ft. Standing water (gal.) =

$$\text{Standing Water Volume} = \pi((\frac{d}{2})^2 + 4) (h)$$

$$3.14 ((\frac{2}{2})^2 + 4) (7) \times 7.48 \text{ gal/ft}^3 = \text{ } \text{ gals.}$$

PID Readings (ppm)

Buret = 0 ppm

Breathing 0.0Well 28.5Purging method PeristalticPurge: Time Start 1012 End 1422

	Time	Water Level	pH	Eh	Conductivity	Temp (C)	DO	Turbidity	Flow Rate ml/min
Initial Reading	<u>1014</u>	<u>7.57</u>	<u>6.46</u>	<u>—</u>	<u>0.365</u>	<u>11.9</u>	<u>4.89</u>	<u>51</u>	<u>80</u>
Final Reading	<u>1430</u>	<u>9.73</u>	<u>6.52</u>	<u>—</u>	<u>0.307</u>	<u>11.8</u>	<u>0.80</u>	<u>7</u>	

Sample Collection: Time Start 1425 End 1428Sample method Peristaltic Bailer Type Samples preserved? Yes

Sample Characteristics (circle all applicable)

Describe odor: none sulfide fishy musty petroleumDescribe color: colorless black brown orange redDescribe appearance: turbid silty sand clay floaters sheenclear multiphased foaming slimy algaeOrganic Layer? None Length? Floating or Sinking or Other? Comments Used disconnected tubingTubing = 6.95 + 5 = 12 feet into wellNote that pump does not run well; stops at mid flow rateRefer to page of the corresponding field log book.

0610

MONITORING WELL SAMPLING WORKSHEET (ADDITIONAL PAGES)

Job Name: Topsfield Niche Job No.: 014947- Samplers: C. RuppelWell ID: NW-6 Date Sampled: 5/23

TAPPC

WS/cm

mg/l

NTU

Flow
ml/min

Time	Water Level ft	pH	Eh	Conductivity	Temp (C)	DO	Turbidity
1017	8.29	6.47	—	0.363	11.0	1.65	44
1020	8.55	6.46	—	0.361	10.9	2.38	41
1023	8.88	6.46	—	0.362	11.0	2.49	104
↳ Pump shut down; turbidity rising							
1052	7.70	Pump started					
1053	8.15	6.40	—	0.367	12.3	2.48	111
1056	8.50	6.43	—	0.365	11.6	1.61	105
1059	8.82	6.46	—	0.355	11.8	3.24	78
1102	8.98	6.45	—	0.355	11.1	19.05	72
1107	9.41	6.46	—	0.353	11.3	15.19	64
1114 Pump has shut itself off; restarting							
1116	9.68	6.42	—	0.331	12.9	1.40	45
1121	10.03	6.44	—	0.333	11.3	2.19	39
1127	10.31	6.45	—	0.330	11.3	2.53	53
1130	10.43	6.46	—	0.331	10.7	2.12	47
1131	Shutting Pump Down						
1226	Pump Restarted			depth = 7.82 feet			
1230	8.38	6.61	—	0.353	12.8	2.16	26
1233	8.66	6.60	—	0.349	12.7	1.45	24
1236	8.86	6.57	—	0.351	12.2	0.95	24
1239	9.03	6.57	—	0.340	12.5	0.79	24
↳ shutting off pump							
1315	Pump restarted			@ 7.67 feet			
1317	8.03	6.58	—	0.345	14.0	3.00	19
1320	8.48	6.57	—	0.340	12.3	2.23	10
1323	8.65	6.55	—	0.330	13.10	0.84	12
1330	9.10	6.52	—	0.313	11.7	0.49	7
1332	Pump shut down						
1410	7.66	6.61	—	0.318	15.3	1.64	7

Pump
Stopped* Was wet by
overflow

130

13 gal removed

12 gal removed

110 ml/min

13 gal removed

130 ml/min

Time	Water Level ft to AC	pH	EH	Conductivity mS/cm	Temp °C	DO mg/l	Turbidity NTU
1413	8.42	6.60	—	0.314	12.2	0.69	5
1416	8.82	6.57	—	0.308	12.2	0.60	7
1419	9.00	6.55	—	0.308	11.8	0.57	5
1422	9.24	6.54	—	0.307	11.7	0.60	6

SAMPLING

MONITORING WELL SAMPLING WORKSHEET

Job Name: TOPSFIELD Job No.: 014947 Samplers: R. BURSAW
 Well ID: MW-07 Date Sampled: 22 May 1996 Time: 8:30 1:16^{am} 1316
 Well Diameter: 2 inch inches + 12 = _____ (d) ft. Well secured upon arrival? ☒ Y
 Depth of well from T.O.C. _____ ft. Depth of water from T.O. PVC 8.1
 Depth to water from T.O.C. _____ ft. Depth of well from T.O. PVC 20.0
 Feet of standing water _____ (h) ft. Standing water (gal.) = _____

Standing Water Volume: $\pi((d)^2 + 4) (h)$
 $3.14 ((2)^2 + 4) (8.1) \times 7.48 \text{ gal/ft}^3 = \underline{\hspace{2cm}} \text{ gal.}$

PID Readings (ppm)

Breathing 0.0
 Well 23.4

Purging method peristaltic pumpPurge: Time Start 8:35 End _____

	Time	Water Level	pH	Eh	Conductivity	Temp (C)	DO	Turbidity
Initial Reading	<u>8:50</u>	<u>9.15</u>	<u>5.73</u>	<u>—</u>	<u>0.332</u>	<u>13.1</u>	<u>13.25</u>	<u>177</u>
Final Reading	<u>11:15</u>	<u>6.92</u>	<u>6.12</u>	<u>—</u>	<u>0.271</u>	<u>11.6</u>	<u>1.22</u>	<u>31</u>

Sample Collection: Time Start 1:07^{am} 1303End 1:05^{am} 1305Sample method peristaltic

Bailer Type _____

Samples preserved? HCL < 2 pH

Sample Characteristics (circle all applicable)

Describe odor: none sulfide fishy musty petroleum _____Describe color: colorless black brown orange red _____

Describe appearance: turbid silty sand clay floaters sheen _____

clear multiphased foaming slimy algae _____Organic Layer? none Length? _____ Floating or Sinking or Other? _____

Comments water from top of pvc = 8' top of screen from top of pvc = 10' 2/3 = 16" from 8" or 9'4" = 23
pump off 8:50, pump on 11:20
11:30 1:05

Refer to page _____ of the corresponding field log book.

MONITORING WELL SAMPLING WORKSHEET

Job Name: TOPSFIELD Job No.: 24947- Samplers: R. BURSAWWell ID: MW-8 Date Sampled: 21 MAR 1996 Time: 1130 1630
Start EndWell Diameter: 2 inch inches + 12 = _____ (d) ft. Well secured upon arrival? Y/NDepth of well from T.O.C. _____ ft. Depth of water from T.O. PVC 6.92Depth to water from T.O.C. _____ ft. Depth of well from T.O. PVC 20.0

Feet of standing water _____ (h) ft. Standing water (gal.) = _____

$$\text{Standing Water Volume} = \pi((d)^2 + 4) (h) \\ 3.14 ((\text{ } \text{ft})^2 + 4) (\text{ } \text{ft}) \times 7.48 \text{ gal/ft}^3 = \text{ } \text{gals.}$$

PID Readings (ppm)

Breathing 2.0Well 0.0Purging method peristaltic pumpPurge: Time Start 11:45 End 4:02

	Time	Water Level	pH	Eh	Conductivity	Temp (C)	DO	Turbidity	Flow ml/min
Initial Reading	<u>11:48</u>	<u>7.45</u>	<u>6.04</u>	<u>—</u>	<u>0.184</u>	<u>16.3</u>	<u>1.64</u>	<u>999</u>	<u>175</u>
Final Reading	<u>4:00</u>	<u>10:03</u>	<u>6.04</u>	<u>—</u>	<u>0.200</u>	<u>17.1</u>	<u>2.11</u>	<u>33</u>	

Sample Collection: Time Start 3:55 End 4:00Sample method peristaltic Bailer Type NASamples preserved? HCL to < 2 pH

Sample Characteristics (circle all applicable)

Describe odor: none sulfide fishy musty petroleumDescribe color: colorless black brown orange redDescribe appearance: turbid silty sand clay floaters sheen

clear multiphased foaming slimy algae

Organic Layer? NO Length? _____ Floating or Sinking or Other? _____Comments 3 well screen vols = ~5 gals. pumped ~4 gals.pump off → 12:25 pump on → 13:0013:26 14:0014:21 15:3315:35 - 15:45

Refer to page _____ of the corresponding field log book.

MONITORING WELL SAMPLING WORKSHEET

Job Name: Topsfield Job No.: 014947 Samplers: C. LaporteWell ID: MW-09 Date Sampled: 5/21/90 Time: 1310 1655
Start EndWell Diameter: 2 inches + 12 = (d) ft. Well secured upon arrival? YNDepth of well from T.O.C. ft. Depth of water from T.O. PVC 7.71Depth to water from T.O.C. ft. Depth of well from T.O. PVC 12.9 ft (bored)Feet of standing water (h) ft. Standing water (gal.) =

$$\text{Standing Water Volume} = \pi ((d)^2 + 4) (h) \\ 3.14 ((2)^2 + 4) (7.71) \times 7.48 \text{ gal/ft}^3 = \text{ } \text{ gals.}$$

PID Readings (ppm)

Top of screen = 9.9 ft
To PVC (bored)Breathing ØWell ØPurging method flush/batterPurge: Time Start 1340 End 1640

	Time	Water Level	pH	Eh	Conductivity	Temp (C)	DO	Turbidity
Initial Reading	<u>1342</u>	<u>8.26</u>	<u>6.20</u>	<u>—</u>	<u>0.208</u>	<u>14.5</u>	<u>4.69</u>	<u>74</u>
Final Reading	<u>See next page</u>							

Sample Collection: Time Start 11040 End 1650Sample method Remotely Bailer Type Samples preserved? yes

Sample Characteristics (circle all applicable)

Describe odor: none sulfide fishy musty petroleumDescribe color: colorless black brown orange red

Describe appearance: turbid silty sand clay floaters sheen

clear multiphased foaming slimy algaeOrganic Layer? None Length? Floating or Sinking or Other? Comments Well screen volume = 1.16 gal 8.9Purging 14.9 ft down -7.7Using 2/3 rule, can draw down ~ 1.5To ~ 9.2 feet below Top PVCRefer to page of the corresponding field log book.

MONITORING WELL SAMPLING WORKSHEET (ADDITIONAL PAGES)

Job Name: Tapsford Job No.: 014974 Samplers: C. RappWell ID: MW-09 Date Sampled: 5/21/90

Time	Water Level	pH	Eh	Conductivity	Temp (C)	DO	Turbidity	Flow Rate ml/min
1340	7.69	6.71	—	0.218	13.0	3.79	1	
1345	8.71	6.71	—	0.223	13.1	3.76	2	
1348	8.96	6.70	—	0.222	13.1	3.77	1	75
1351	9.14	6.70	—	0.224	13.1	3.80	1	
1354	9.18	6.70	—	0.223	13.3	4.05	1	
1358	9.24	6.68	—					
1359	Pump Shut Down							~1/3 gal removed
1429	8.12	Pump Turned Back on						
1432	8.42	—	—	—	—	4.72	2	
1436	8.25	6.71	—	0.222	13.5	5.31	1	
1439	8.91	6.69	—	0.221	13.2	5.25	Ø	
1443	9.12	6.73	—	0.221	13.1	5.44	Ø	
1444	9.19	6.68	—	0.223	12.7	4.26	Ø	
1445	Pump shut off							2/3 gal removed ~100 ml/min
1515	8.16	6.69	—	0.214	13.5	6.07	Ø	
1519	8.88	6.69	—	0.220	13.6	3.85	Ø	
1522	8.96	6.69	—	0.220	13.3	3.60	Ø	
1525	9.02	6.67	—	0.220	13.3	3.62	Ø	>1 gal
1528	9.11	6.65	—	0.224	13.0	3.35	Ø	
1531	9.15	6.64	—	0.221	13.2	3.17	Ø	
1532	9.18	Pump Shut down						
1606	8.13	Started Pump Again						~1.5 gal
1611	8.61	6.68	—	0.219	16.1	3.68	Ø	
1614	8.72	6.66	—	0.218	14.4	3.54	Ø	
1619	8.75	6.65	—	0.220	13.7	3.14	Ø	
1625	8.79	6.63	—	0.220	14.3	3.59	Ø	2 gal removed
1628	8.99	6.61	—	0.218	12.7	3.42	Ø	
1631	9.12	6.59	—	0.217	11.8	2.94	Ø	

Pump shut itself off, restarted

MONITORING WELL SAMPLING WORKSHEET

Job Name: Topsfield Job No.: 614947 Samplers: J. Verban / C LaporteWell ID: MW 101 (shallow) Date Sampled: 8-12-96 Time: 1200 1545
Start EndWell Diameter: 2. inches + 12 = (d) ft. Well secured upon arrival? (Y)NDepth of well from T.O.C. 32.4 ft.Depth of water from T.O. PVC 25.0Depth to water from T.O.C. 25.0 ft.Depth of well from T.O. PVC 32.4Feet of standing water 6.6 (h) ft.Standing water (gal.) = 0.6

Standing Water Volume: $\pi((d)^2 \div 4) (h)$
 $3.14 ((\text{ft})^2 \div 4) (\text{ft}) \times 7.48 \text{ gal/ft}^3 = \text{gal.}$

PID Readings (ppm)

Breathing 0.0Well 2.0Purging method Low flowPurge: Time Start 12:18 End

	Time	Water Level	pH	Eh	Conductivity	Temp (C)	DO	Turbidity
Initial Reading	<u>12:10</u>	<u>29.95'</u>	<u>7.22</u>	<u> </u>	<u>.245</u>	<u>16.4</u>	<u>5.91</u>	<u>1999.</u>
Final Reading	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>

Sample Collection: Time Start 1515End 1530 HOD anSample method Peristaltic PumpBailer Type Samples preserved? yes

Sample Characteristics (circle all applicable)

Describe odor: none sulfide fishy musty petroleum Describe color: colorless black brown orange red Describe appearance: turbid slightly silty sand clay floaters sheen clear multiphased foaming slimy algae Organic Layer? none Length? Floating or Sinking or Other?

Comments Well was pumped to dryness and allowed
to recharge until sufficient volume was
available for sampling. Water levels
Recovered extremely slowly.

Refer to page of the corresponding field log book.

Well ID: MW 101 Date Sampled: 8-12-96

[illegible]

MONITORING WELL SAMPLING WORKSHEET

Job Name: Topfield Job No.: 014947 Samplers: CRWell ID: MW-100 Date Sampled: 8/12/96 Time: 1130 1500
Start EndWell Diameter: 2 inches + 12 = _____ (d) ft. Well secured upon arrival? YDepth of well from T.O.C. _____ ft. Depth of water from T.O. PVC 27.73 ftDepth to water from T.O.C. _____ ft. Depth of well from T.O. PVC 246.5 ft

Feet of standing water _____ (h) ft. Standing water (gal.) = _____

$$\text{Standing Water Volume} = \pi((d)^2 + 4) (h) \\ 3.14 ((\text{ft})^2 + 4) (\text{ft}) \times 7.48 \text{ gal/ft}^3 = \text{gal.}$$

PID Readings (ppm)

Breathing ØWell 11.2Purging method Low Flow Purge: Time Start 1225 End _____

	Time	Water Level	pH	Eh	Conductivity	Temp (C)	DO	Turbidity
Initial Reading	_____	_____	_____	_____	_____	_____	_____	_____
Final Reading	_____	_____	_____	_____	_____	_____	_____	_____

Sample Collection: Time Start 1445 End 1500Sample method Bailer Bailer Type _____Samples preserved? Yes

Sample Characteristics (circle all applicable)

Describe odor: none sulfide fishy musty petroleum _____Describe color: colorless black brown orange red _____Describe appearance: turbid slightly silty sand clay floaters sheen _____

clear multiphased foaming slimy algae _____

Organic Layer? none Length? _____ Floating or Sinking or Other? _____Comments 36.5 to TotS from TotPVC

+5
+1.5 ft of tubing from TotPVC
7.5 mls =
33.65 ft
well screen vol = 1.6 gal
well screen volumes = 4.8 gal

Refer to page _____ of the corresponding field log book.

APPENDIX D
RISK CHARACTERIZATION TABLES

TABLE D-1. SAMPLES USED IN THE CALCULATION OF SOIL EXPOSURE POINT CONCENTRATIONS

SAMPLE	DEPTH	DATE	ANALYSES
UST-1 Area Soil (a)			
UT-1	---	1987	TPH, BTEX
B-4	---	1991	TPH
SB-1	6'-8'	1994	TPH, BTEX, selected PAHs(c)
SB-1	10'-12'	1994	TPH, BTEX, selected PAHs(c)
SB-2	6'-8 1/2'-8'	1994	TPH, BTEX, selected PAHs(c)
SB-2	10'-12'	1994	TPH, BTEX, selected PAHs(c)
SB-3	4'-6 1/4'-8'	1994	TPH, BTEX, selected PAHs(c)
SB-3	10'-12'	1994	TPH, BTEX, selected PAHs(c)
SB-4	8'-10 1/6'-10'	1994	TPH, BTEX, selected PAHs(c)
SB-4	10'-12 1/10'-14'	1994	TPH, BTEX, selected PAHs(c)
SB-5	8'-10 1/2'-10'	1994	TPH, BTEX, selected PAHs(c)
SB-5D	duplicate of SB-5(8-10/2-10)	1994	TPH, BTEX, selected PAHs(c)
SB-5	12'-14 1/10'-16'	1994	TPH, BTEX, selected PAHs(c)
SB-5D	duplicate of SB-5(12-14/10-16)	1994	TPH, BTEX, selected PAHs(c)
SB-7	8'-10'	1994	TPH, BTEX, selected PAHs(c)
SB-7	15'-17'	1994	TPH, BTEX, selected PAHs(c)
SB-15	13'-15'	1996	VPH/EPH, VOCs, SVOCs
SB-19	6'-7'	1996	VPH/EPH, VOCs, SVOCs
SB-20	2'-4 1/0'-4'	1996	VPH/EPH, VOCs, SVOCs
SB-20	4'-6'	1996	VPH/EPH, VOCs, SVOCs
UST-2 Area Soil (b)			
UST-2N	---	1992	TPH
SB-9	0'-2'	1994	TPH
SB-13	4'-6'	1994	TPH
MW/SB-100	7'-9'	1996	chlorinated VOCs
MW/SB-100	22'-24'	1996	chlorinated VOCs
MW/SB-101	9'-11'	1996	chlorinated VOCs
MW/SB-101	duplicate of SB-101(9-11)	1996	chlorinated VOCs
MW/SB-101	16'-18'	1996	chlorinated VOCs

NOTES:

- See Figure 3-2 for UST-1 sample locations.
- See Figure 3-3 for UST-2 sample locations.
- Selected PAHs include naphthalene, 2-methylnaphthalene, and phenanthrene.

TABLE D-2. EXPOSURE POINT CONCENTRATIONS FOR UST-1 AREA SOILS

Contaminant of Concern (a)	Sample: Depth: Date:	Sampling Data (mg/kg) (continued)								
		UT-1	B-4	SB-1 (6-8)	SB-1 (10-12)	SB-2 (6-8) / (2-8)	SB-2 (10-12)	SB-3 (4-6)/(4-8)	SB-3 (10-12)	SB-4 (8-10) / (6-10)
		1987	1991	1994	1994	1994	1994	1994	1994	1994
TPH (mg/kg)		320	450	< 3.6	126	515	3880	493	37.3	140
VPH (mg/kg)		NA	NA	NA	NA	NA	NA	NA	NA	NA
C5-C8 aliphatics										
C9-C12 aliphatics										
C9-C10 aromatics										
EPH (mg/kg)		NA	NA	NA	NA	NA	NA	NA	NA	NA
C9-C18 aliphatics										
C19-C36 aliphatics										
C11-C22 aromatics										
VOCs (mg/kg)										
Benzene		< 0.05	NA	< 0.28	< 0.055	< 0.06	< 0.0043	< 0.0055	0.0062	< 0.0011 J
sec-Butylbenzene		NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene		< 0.05	NA	< 0.28	< 0.055	< 0.06	< 0.0043	< 0.0055	0.12	< 0.0011 J
Isopropylbenzene		NA	NA	NA	NA	NA	NA	NA	NA	NA
p-Isopropyltoluene		NA	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene		NA	NA	NA	NA	NA	NA	NA	NA	NA
n-Propylbenzene		NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene		NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3,5-Trimethylbenzene		NA	NA	NA	NA	NA	NA	NA	NA	NA
Xylenes (total)		< 0.05	NA	< 0.28	< 0.055	< 0.06	< 0.0043	< 0.0055	0.23	< 0.0011 J
SVOCs (mg/kg)										
Acenaphthene		NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthylene		NA	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene		NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene		NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene		NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene		NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene		NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene		NA	NA	NA	NA	NA	NA	NA	NA	NA
Butylbenzylphthalate		NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene		NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene		NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran		NA	NA	NA	NA	NA	NA	NA	NA	NA
Di-n-octylphthalate		NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene		NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene		NA	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene		NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene		NA	NA	11	0.67	< 0.38	24	< 0.37	< 0.37	< 0.37
Naphthalene		NA	NA	1.5	< 0.36	< 0.38	1.7	< 0.37	< 0.37	< 0.37
N-Nitrosodiphenylamine		NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene		NA	NA	2.2	1.3	< 0.38	6.8	0.6	0.6	< 0.37
Pyrene		NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE D-2 (CONTINUED). EXPOSURE POINT CONCENTRATIONS FOR UST-1 AREA SOILS

Contaminant of Concern (a)	Sample: Depth: Date:	Sampling Data (mg/kg)						(continued)	
		SB-4	SB-5	SB-5D	SB-5	SB-5D	SB-7	SB-7	
		(10-12)	(8-10)/(2-10)		(12-14)/(10-16)		(8-10)	(15-17)	
		/(10-14)	duplicate samples		duplicate samples		1994	1994	
TPH (mg/kg)		134	201 J	358 J	150	107	741	32.1	
VPH (mg/kg)		NA	NA	NA	NA	NA	NA	NA	
C5-C8 aliphatics									
C9-C12 aliphatics									
C9-C10 aromatics									
EPH (mg/kg)		NA	NA	NA	NA	NA	NA	NA	
C9-C18 aliphatics									
C19-C36 aliphatics									
C11-C22 aromatics									
VOCs (mg/kg)									
Benzene		< 0.0011 J	< 0.0011 J	< 0.0011 J	< 0.0011 J	< 0.0011 J	< 0.30	< 0.055	
sec-Butylbenzene		NA	NA	NA	NA	NA	NA	NA	
Ethylbenzene		< 0.0011 J	< 0.0011 J	< 0.0011 J	< 0.0011 J	< 0.0011 J	< 0.30	< 0.055	
Isopropylbenzene		NA	NA	NA	NA	NA	NA	NA	
p-Isopropyltoluene		NA	NA	NA	NA	NA	NA	NA	
Naphthalene		NA	NA	NA	NA	NA	NA	NA	
n-Propylbenzene		NA	NA	NA	NA	NA	NA	NA	
1,2,4-Trimethylbenzene		NA	NA	NA	NA	NA	NA	NA	
1,3,5-Trimethylbenzene		NA	NA	NA	NA	NA	NA	NA	
Xylenes (total)		< 0.0011 J	< 0.0011 J	< 0.0011 J	< 0.0011 J	< 0.0011 J	< 0.30	< 0.055	
SVOCs (mg/kg)									
Acenaphthene		NA	NA	NA	NA	NA	NA	NA	
Acenaphthylene		NA	NA	NA	NA	NA	NA	NA	
Anthracene		NA	NA	NA	NA	NA	NA	NA	
Benzo(a)anthracene		NA	NA	NA	NA	NA	NA	NA	
Benzo(a)pyrene		NA	NA	NA	NA	NA	NA	NA	
Benzo(b)fluoranthene		NA	NA	NA	NA	NA	NA	NA	
Benzo(g,h,i)perylene		NA	NA	NA	NA	NA	NA	NA	
Benzo(k)fluoranthene		NA	NA	NA	NA	NA	NA	NA	
Butylbenzylphthalate		NA	NA	NA	NA	NA	NA	NA	
Chrysene		NA	NA	NA	NA	NA	NA	NA	
Dibenzo(a,h)anthracene		NA	NA	NA	NA	NA	NA	NA	
Dibenzofuran		NA	NA	NA	NA	NA	NA	NA	
Di-n-octylphthalate		NA	NA	NA	NA	NA	NA	NA	
Fluoranthene		NA	NA	NA	NA	NA	NA	NA	
Fluorene		NA	NA	NA	NA	NA	NA	NA	
Indeno(1,2,3-cd)pyrene		NA	NA	NA	NA	NA	NA	NA	
2-Methylnaphthalene		< 0.35	< 0.36	< 0.36	< 0.36	< 0.36	3.0 J	< 0.36	
Naphthalene		< 0.35	< 0.36	< 0.36	< 0.36	< 0.36	0.41 J	< 0.36	
N-Nitrosodiphenylamine		NA	NA	NA	NA	NA	NA	NA	
Phenanthrene		< 0.35	< 0.36	< 0.36	< 0.36	< 0.36	0.93	< 0.36	
Pyrene		NA	NA	NA	NA	NA	NA	NA	

TABLE D-2 (CONTINUED). EXPOSURE POINT CONCENTRATIONS FOR UST-1 AREA SOILS

Contaminant of Concern (a)	Sample: Depth: Date:	Sampling Data (mg/kg)				Frequency of Detections	UST-1 Area Exposure Point Concentration		
		SB-15 (13-15)	SB-19 (6-7)	SB-20 (2-4) / (0-4)	SB-20 (4-6)		Maximum Detected	Average (b)	Percentage (c)
		1996	1996	1996	1996				
TPH (mg/kg)		NA	NA	NA	NA	12 / 13	3880	560	
VPH (mg/kg)									
C5-C8 aliphatics		7.07 J	11.69 J	4.30 J	11.54 J	4 / 4	11.69 J	8.7	1%
C9-C12 aliphatics		15.74	203.5	2.76	137.3	4 / 4	203.5	90	9%
C9-C10 aromatics		15.28	166.8	0.96	129.0	4 / 4	166.8	78	8%
EPH (mg/kg)									
C9-C18 aliphatics		289.4 J	1025	9.69	839.0	4 / 4	1025	541	53%
C19-C36 aliphatics		32.48 J	112.8	8.62	91.05	4 / 4	112.8	61	6%
C11-C22 aromatics		188.8	443.6 J	19.00	324.6	4 / 4	443.6 J	244	24%
VOCs (mg/kg)									
Benzene		< 0.006	< 0.006	< 0.006	< 0.005	1 / 17	0.0062	0.0062 *	
sec-Butylbenzene		0.012	0.058	< 0.006	< 0.005	2 / 4	0.058	0.019	
Ethylbenzene		0.001 J	< 0.006	< 0.006	< 0.005	2 / 17	0.12	0.032	
Isopropylbenzene		0.004 J	0.013	< 0.006	< 0.055	2 / 4	0.013	0.012	
p-Isopropyltoluene		0.013 J	0.041	< 0.006	0.018	3 / 4	0.041	0.019	
Naphthalene		< 0.058	0.20	< 0.060	< 0.005	1 / 4	0.2	0.065	
n-Propylbenzene		0.009	0.027	< 0.006	0.002 J	3 / 4	0.027	0.010	
1,2,4-Trimethylbenzene		0.008	< 0.006	< 0.006	< 0.005	1 / 4	0.008	0.004	
1,3,5-Trimethylbenzene		0.011	< 0.006	< 0.006	< 0.005	1 / 4	0.011	0.004	
Xylenes (total)		< 0.006	< 0.006	< 0.006	< 0.005	1 / 17	0.23	0.038	
SVOCs (mg/kg)									
Acenaphthene		< 0.36	< 0.75	< 0.038	1.4 J	1 / 4	1.4	0.494	
Acenaphthylene		< 0.36	< 0.75	0.013 J	< 7.4	1 / 4	0.013	0.013 *	
Anthracene		< 0.36	0.34 J	0.009 J	0.56 J	3 / 4	0.56	0.272	
Benzo(a)anthracene		< 0.36	0.014 J	0.046 J	< 7.4	2 / 4	0.046	0.046 *	
Benzo(a)pyrene		< 0.36	< 0.75	0.053 J	< 7.4	1 / 4	0.053	0.053 *	
Benzo(b)fluoranthene		< 0.36	< 0.75	0.047 J	< 7.4	1 / 4	0.047	0.047 *	
Benzo(g,h,i)perylene		< 0.36	< 0.75	0.034 J	< 7.4	1 / 4	0.034	0.034 *	
Benzo(k)fluoranthene		< 0.36	< 0.75	0.057 J	< 7.4	1 / 4	0.057	0.057 *	
Butylbenzylphthalate		< 0.36	< 0.75	0.032 J	< 7.4	1 / 4	0.032	0.032 *	
Chrysene		< 0.36	0.022 J	0.074 J	< 7.4	2 / 4	0.074	0.074 *	
Dibenzo(a,h)anthracene		< 0.36	< 0.75	0.01 J	< 7.4	1 / 4	0.01	0.010 *	
Dibenzofuran		< 0.36	< 0.75	0.015 J	0.97 J	2 / 4	0.97	0.385	
Di-n-octylphthalate		0.043 J	0.016 J	< 0.038	< 7.4	2 / 4	0.043	0.043 *	
Fluoranthene		0.007 J	0.061 J	0.16 J	0.098 J	4 / 4	0.16	0.082	
Fluorene		0.11 J	1.4	0.01 J	2.0 J	4 / 4	2	0.880	
Indeno(1,2,3-cd)pyrene		< 0.36	< 0.75	0.034 J	< 7.4	1 / 4	0.034	0.034 *	
2-Methylnaphthalene		0.64	< 0.75	0.01 J	25	7 / 16	25	4.135	
Naphthalene		0.067 J	1.0	0.025 J	3.9 J	7 / 16	3.9	0.640	
N-Nitrosodiphenylamine		< 0.36	1.2	< 0.038	1.8 J	2 / 4	1.8	0.800	
Phenanthrene		< 0.36	< 0.75	< 0.038	< 7.4	6 / 16	2.2	1.112	
Pyrene		0.008 J	0.12 J	0.15 J	0.14 J	4 / 4	0.15	0.105	

TABLE D-2 (CONTINUED). EXPOSURE POINT CONCENTRATIONS FOR UST-1 AREA SOILS

NOTES:

- a. Analytes listed are those detected in soils associated with UST-1.
 - b. One-half of the non-detected results were used in calculating the average concentrations.
 - c. Percentages are calculated for VPH/EPH fractions for use with TPH data.
- (0 - 2) - Numbers in parentheses are sample depths. Where two intervals are presented, the first applies to the VPH and/or VOC analysis, the second to the remaining analyses.
- < - Not detected at or above laboratory detection limits. Number presented is the detection limit.
- J - Estimated concentration
- NA - Not analyzed
- - The maximum detected value is used; the mean was greater than the maximum due to elevated detection limits.

TABLE D-3. EXPOSURE POINT CONCENTRATIONS FOR UST-2 AREA SOILS

Contaminants of Concern (a)	Sample:	Sampling Data (mg/kg)							Frequency of Detection	Exposure Point Concentrations		
	Depth:	UST-2N	SB-9 (0-2)	SB-13 (4-6)	SB-100 (7-9)	SB-100 (22-24)	SB-101 (9-11)	SB-101 (9-11)		SB-101 (16-18)	Maximum Detected	Average (b)
	Date:	1992	1994	1994	1996	1996	duplicate samples 1996			1996		
TPH (mg/kg)		1,100	221	145	NA	NA	NA	NA	NA	3 / 3	1,100	489
VOCs (mg/kg)												
2-Butanone (MEK)		NA	NA	NA	< 0.011	< 0.011	0.002 J	< 0.011	< 0.011	1 / 4	0.002	0.002 *
1,1-Dichloroethane		NA	NA	NA	<0.006	0.002 J	<0.006	<0.006	<0.006	1 / 4	0.002	0.002 *
1,1-Dichloroethene		NA	NA	NA	<0.006	0.002 J	<0.006	<0.006	<0.006	1 / 4	0.002	0.002 *

NOTES:

- Analytes listed are those detected in soils associated with UST-2.
- Average generated using 1/2 detection limit where not detected.

(0 - 2) - Numbers in parentheses are sample depths. Where two intervals are presented, the first applies to the TPH and/or VOC analysis, the second to the remaining analyses.

< - Not detected at or above laboratory detection limits. Number presented is the detection limit.

J - Estimated concentration

NA - Not analyzed

* - The maximum detected value is used; the mean was greater than the maximum due to elevated detection limits.

TABLE D-4. EXPOSURE POINT CONCENTRATIONS FOR UST-1 AREA GROUNDWATER

Contaminants of Concern (a)	Location:	Sampling Data (ug/L)								Frequency of Detections	UST-1 Area Maximum	
	Date:	MW-1	MW-1	B-4	MW-5	MW-6	MW-1	MW-4	MW-5			MW-6
		duplicate samples										
		1994		1994	1994	1994	1996	1996	1996	1996		
VOCs (ug/L)												
1,1-Dichloroethane		NA	NA	NA	NA	NA	<5.0	0.6 J	<5.0	0.6 J	1 / 4	0.6
1,1,1-Trichloroethane		NA	NA	NA	NA	NA	<5.0	<5.0	0.7 J	<5.0	1 / 4	0.7
Trichloroethene		NA	NA	NA	NA	NA	<5.0	1.0 J	0.5 J	<5.0	2 / 4	1.0

NOTES:

a. Analytes listed are those detected in groundwater in the UST-1 area, other than the background sample, in 1994 or 1996.

< - Not detected at or above laboratory detection limits. Number presented is the detection limit.

J - Estimated concentration

NA - Not analyzed

TABLE D-5. EXPOSURE POINT CONCENTRATIONS FOR UST-2 AREA GROUNDWATER

Contaminants of Concern (a)	Sampling Data (ug/L)					Frequency of Detections	UST-2 Area (b) Maximum
	MW-7	MW-8	MW-9	MW-100	MW-101		
VOCs (ug/L)							
1,1-Dichloroethane	<5.0	<5.0	19	<5.0	<5.0	1 / 5	19
1,1-Dichloroethene	<5.0	<5.0	5	<5.0	<5.0	1 / 5	5
1,1,1-Trichloroethane	<5.0	0.8 J	130	<5.0	<5.0	2 / 5	130
Trichloroethene	1 J	0.9 J	20	<5.0	<5.0	3 / 5	20

NOTES:

- Analytes listed are those detected in groundwater in the UST-2 area in 1996.
- Some reported levels of chlorinated VOCs were higher in 1994, but the results were not calibrated since these compounds were not targeted analytes.

< - Not detected at or above laboratory detection limits. Number presented is the detection limit.

J - Estimated concentration

D-6. DOSE-RESPONSE DATA FOR INGESTION AND DERMAL EXPOSURES

Contaminant of Concern	Chronic RfD (mg/kg-day)	Critical Effect	RfD Confidence	REF	Oral Slope Factor (mg/kg-day)	Weight of Evidence	REF
TPH (mg/kg)							
C5-C9 aliphatics	0.06	neurotoxicity for n-hexane	NA	(4)	NC	NA	(4)
C9-C12 aliphatics	0.6	neurotoxicity for n-nonane	NA	(4)	NC	NA	(4)
C9-C10 aromatics	0.03	neurotoxicity for pyrene	NA	(4)	NC	NA	(4)
C9-C18 aliphatics	0.6	neurotoxicity for n-nonane	NA	(4)	NC	NA	(4)
C19-C36 aliphatics	6.0	irritation for eicosane	NA	(4)	NC	NA	(4)
C11-C22 aromatics	0.03	neurotoxicity for pyrene	NA	(4)	NC	NA	(4)
VOCs (mg/kg)							
Benzene	0.005	NA	NA	(3)	0.029	A	(1)
2-Butanone (MEK)	0.600	decreased fetal weight	Low	(1)	NC	D	(1)
sec-Butylbenzene	0.01	NA	NA	(5)	NA	NA	
1,1-Dichloroethane	0.1	none observed	NA	(2)	NA	C	(1)
1,1-Dichloroethene	0.009	liver toxicity	Medium	(1)	0.6	C	(1)
Ethylbenzene	0.1	liver and kidney toxicity	Low	(1)	NC	D	(1)
Isopropylbenzene	0.1	increased kidney weight	Low	(1)	NC	D	(1)
n-Propylbenzene	NA	NA	NA		NA	NA	
p-Isopropyltoluene	NA	NA	NA		NA	NA	
1,2,4-Trimethylbenzene	0.05	NA	NA	(5)	NA	NA	
1,3,5-Trimethylbenzene	0.05	NA	NA	(5)	NA	NA	
Xylenes (total)	2	hyperactivity, decreased body weight, mortality	Medium	(1)	NC	D	(1)
SVOCs (mg/kg)							
Acenaphthene	0.06	liver toxicity	Low	(1)	NC	D	(3)
Acenaphthylene	0.04	NA	NA	(3)	NC	D	(1)
Anthracene	0.3	no observed effects	Low	(1)	NC	D	(1)
Benzo(a)anthracene	0.04	NA	NA	(3)	0.73	B2	(3)
Benzo(a)pyrene	0.04	NA	NA	(3)	7.3	B2	(1)
Benzo(b)fluoranthene	0.04	NA	NA	(3)	0.73	B2	(3)
Benzo(g,h,i)perylene	0.04	NA	NA	(3)	NC	D	(1)
Benzo(k)fluoranthene	0.04	NA	NA	(3)	0.073	B2	(3)
Butylbenzylphthalate	0.2	increased liver weight	Low	(1)	NA	C	(1)
Chrysene	0.04	NA	NA	(3)	0.073	B2	(3)
Dibenzo(a,h)anthracene	0.04	NA	NA	(3)	7.3	B2	(3)
Dibenzofuran	0.004	NA	NA	(5)	NC	D	
Di-n-octylphthalate	0.02	liver and kidney toxicity	NA	(2)	NA	NA	
Fluoranthene	0.04	kidney, liver, and blood cell effects	Low	(1)	NC	D	(1)
Fluorene	0.04	decreased volume of red blood cells	Low	(1)	NC	D	(1)
Indeno(1,2,3-cd)pyrene	0.04	NA	NA	(3)	0.73	B2	(3)
2-Methylnaphthalene	0.04	NA	NA	(3)	NA	NA	
Naphthalene	0.04	NA	NA	(3)	NC	D	(1)
N-Nitrosodiphenylamine	NA	NA	NA	(5)	0.0049	B2	(1)
Phenanthrene	0.04	NA	NA	(3)	NC	D	(1)
Pyrene	0.03	kidney effects, neurotoxicity	Low	(1)	NC	D	(1)

References (REF):

1. EPA, 1997. *Integrated Risk Information System (IRIS)*
2. EPA, 1995. *Health Effects Assessment Summary Tables (HEAST)*
3. MADEP, 1994. *Background Documentation*, Table 2.1
4. MADEP, 1997. *Implementation of the MADEP VPH/EHP Approach*
5. Reg. III, EPA, 1997. *Risk-Based Concentrations*

NA - Not available

NC - Not carcinogen

D-7. RELATIVE ABSORPTION FACTORS FOR INGESTION AND DERMAL EXPOSURES

Contaminant of Concern	Ingestion, Soil (a)		Dermal Contact, Soil (a)	
	Noncancer RAF	Cancer RAF	Noncancer RAF	Cancer RAF
TPH (mg/kg)				
C5-C9 aliphatics	0.91	NC	0.50	NC
C9-C12 aliphatics	0.91	NC	0.20	NC
C9-C10 aromatics	0.91	NC	0.18	NC
C9-C18 aliphatics	0.91	NC	0.20	NC
C19-C36 aliphatics	0.91	NC	0.10	NC
C11-C22 aromatics	0.91	NC	0.18	NC
VOCs (mg/kg)				
Benzene	1	1	0.08	0.08
2-Butanone (MEK)	1	NC	0.1	NC
sec-Butylbenzene	NA	NA	NA	NA
1,1-Dichloroethane	1.3	NC	0.13	NC
1,1-Dichloroethene	1	1.02	0.1	0.102
Ethylbenzene	1	NC	0.2	NC
Isopropylbenzene	NA	NA	NA	NA
n-Propylbenzene	NA	NA	NA	NA
p-Isopropyltoluene	NA	NA	NA	NA
1,2,4-Trimethylbenzene	NA	NA	NA	NA
1,3,5-Trimethylbenzene	NA	NA	NA	NA
Xylenes (total)	1	NC	0.12	NC
SVOCs (mg/kg)				
Acenaphthene	1	NC	0.2	NC
Acenaphthylene	0.91	NC	0.18	NC
Anthracene	1	NC	0.29	NC
Benzo(a)anthracene	0.91	1	0.18	0.2
Benzo(a)pyrene	0.91	1	0.18	0.2
Benzo(b)fluoranthene	0.91	1	0.18	0.2
Benzo(g,h,i)perylene	0.91	NC	0.18	NC
Benzo(k)fluoranthene	0.91	1	0.18	0.2
Butylbenzylphthalate	NA	NA	NA	NA
Chrysene	0.91	1	0.18	0.2
Dibenzo(a,h)anthracene	0.91	1	0.08	0.09
Dibenzofuran	NA	NA	NA	NA
Di-n-octylphthalate	NA	NA	NA	NA
Fluoranthene	1	NC	0.2	NC
Fluorene	1	NC	0.2	NC
Indeno(1,2,3-cd)pyrene	0.91	1	0.18	0.2
2-Methylnaphthalene	1	NC	0.1	NC
Naphthalene	1	NC	0.1	NC
N-Nitrosodiphenylamine	NA	NA	NA	NA
Phenanthrene	0.91	NC	0.18	NC
Pyrene	1	NC	0.2	NC

NOTES:

- All RAF values taken from *Background Documentation*, Table 2.1 (MADEP, 1994), except for TPH RAFs which are taken from *Implementation of the MADEP VPH/EHP Approach* (MADEP, 1997)

NA - Not available

NC - Not carcinogen

TABLE D-8. AVERAGE DAILY DOSE AND HAZARD INDEX CALCULATIONS FOR RESIDENTIAL EXPOSURES TO UST1 SOIL, AVERAGE CONCENTRATIONS

Contaminant of Concern	UST-1 Area Average (a) (mg/kg)	Chronic Soil Ingestion Exposure		Chronic Soil Dermal Contact Exposure		Chronic RfD (b) (mg/kg-day)	Chemical-Specific Hazard Quotient		Chemical-Specific Hazard Index
		RAF (b)	ADD (c) (mg/kg-day)	RAF (b)	ADD (d) (mg/kg-day)		Ingestion (e)	Dermal (e)	
TPH (mg/kg)	560								
C5-C9 aliphatics (1%)	5.60	0.91	1.6E-5	0.5	8.0E-5	0.06	2.6E-4	1.3E-3	1.6E-3
C9-C12 aliphatics (9%)	50.4	0.91	1.4E-4	0.2	2.9E-4	0.6	2.4E-4	4.8E-4	7.2E-4
C9-C10 aromatics (8%)	44.8	0.91	1.3E-4	0.18	2.3E-4	0.03	4.2E-3	7.7E-3	1.2E-2
C9-C18 aliphatics (53%)	297	0.91	8.4E-4	0.20	1.7E-3	0.6	1.4E-3	2.8E-3	4.2E-3
C19-C36 aliphatics (6%)	33.6	0.91	9.5E-5	0.10	9.6E-5	6.0	1.6E-5	1.6E-5	3.2E-5
C11-C22 aromatics (24%)	134	0.91	3.8E-4	0.18	6.9E-4	0.03	1.3E-2	2.3E-2	3.6E-2
VOCs (mg/kg)									
Benzene	0.0062	1	1.9E-8	0.08	1.4E-8	5.00E-03	3.8E-6	2.8E-6	6.7E-6
sec-Butylbenzene	0.019	1 (f)	5.9E-8	0.2 (f)	1.1E-7	0.01	5.9E-6	1.1E-5	1.7E-5
Ethylbenzene	0.032	1	9.8E-8	0.2	1.8E-7	0.1	9.8E-7	1.8E-6	2.8E-6
Xylenes (total)	0.038	1	1.2E-7	0.12	1.3E-7	2	5.9E-8	6.5E-8	1.2E-7
Isopropylbenzene	0.012	1 (f)	3.7E-8	0.2 (f)	6.8E-8	0.1	3.7E-7	6.8E-7	1.0E-6
p-Isopropyltoluene	0.019	1 (f)	5.8E-8	0.2 (f)	1.1E-7	NA	NA	NA	NA
n-Propylbenzene	0.010	1 (f)	3.2E-8	0.2 (f)	5.8E-8	NA	NA	NA	NA
1,2,4-Trimethylbenzene	0.004	1 (f)	1.2E-8	0.2 (f)	2.2E-8	5.00E-02	2.4E-7	4.4E-7	6.8E-7
1,3,5-Trimethylbenzene	0.004	1 (f)	1.3E-8	0.2 (f)	2.4E-8	5.00E-02	2.6E-7	4.8E-7	7.5E-7
SVOCs (mg/kg)									
Acenaphthene	0.494	1	1.5E-6	0.2	2.8E-6	0.06	2.5E-5	4.7E-5	7.2E-5
Acenaphthylene	0.013	0.91	3.7E-8	0.18	6.7E-8	0.04	9.2E-7	1.7E-6	2.6E-6
Anthracene	0.272	1	8.4E-7	0.29	2.3E-6	0.3	2.8E-6	7.5E-6	1.0E-5
Benzo(a)anthracene	0.046	0.91	1.3E-7	0.18	2.4E-7	0.04	3.2E-6	5.9E-6	9.1E-6
Benzo(a)pyrene	0.053	0.91	1.5E-7	0.18	2.7E-7	0.04	3.7E-6	6.8E-6	1.1E-5
Benzo(b)fluoranthene	0.047	0.91	1.3E-7	0.18	2.4E-7	0.04	3.3E-6	6.0E-6	9.3E-6
Benzo(g,h,i)perylene	0.034	0.91	9.6E-8	0.18	1.7E-7	0.04	2.4E-6	4.4E-6	6.8E-6
Benzo(k)fluoranthene	0.057	0.91	1.6E-7	0.18	2.9E-7	0.04	4.0E-6	7.3E-6	1.1E-5
Butylbenzylphthalate	0.032	1 (f)	9.9E-8	0.2 (f)	1.8E-7	0.2	5.0E-7	9.1E-7	1.4E-6
Chrysene	0.074	0.91	2.1E-7	0.18	3.8E-7	0.04	5.2E-6	9.5E-6	1.5E-5
Dibenzo(a,h)anthracene	0.010	0.91	2.8E-8	0.08	2.3E-8	0.04	7.1E-7	5.7E-7	1.3E-6
Dibenzofuran	0.385	1 (f)	1.2E-6	0.2 (f)	2.2E-6	0.004	3.0E-4	5.5E-4	8.5E-4
Di-n-octylphthalate	0.043	1 (f)	1.3E-7	0.2 (f)	2.5E-7	0.02	6.7E-6	1.2E-5	1.9E-5
Fluoranthene	0.082	1	2.5E-7	0.2	4.6E-7	0.04	6.3E-6	1.2E-5	1.8E-5
Fluorene	0.880	1	2.7E-6	0.2	5.0E-6	0.04	6.8E-5	1.3E-4	1.9E-4
Indeno(1,2,3-cd)pyrene	0.034	0.91	9.6E-8	0.18	1.7E-7	0.04	2.4E-6	4.4E-6	6.8E-6
2-Methylnaphthalene	4.135	1	1.3E-5	0.1	1.2E-5	0.04	3.2E-4	2.9E-4	6.2E-4
N-Nitrosodiphenylamine	0.800	1 (f)	2.5E-6	0.2 (f)	4.6E-6	NA	NA	NA	NA
Naphthalene	0.640	1	2.0E-6	0.1	1.8E-6	0.04	5.0E-5	4.6E-5	9.5E-5
Phenanthrene	1.112	0.91	3.1E-6	0.18	5.7E-6	0.04	7.8E-5	1.4E-4	2.2E-4
Pyrene	0.105	1	3.2E-7	0.2	6.0E-7	0.03	1.1E-5	2.0E-5	3.1E-5

TOTAL HAZARD INDEX = 0.04

NOTES:

- Mean concentrations and TPH fraction percentages from Table D-2.
- RfD and RAF values taken from Tables D-6 and D-7, respectively.
- The soil ingestion average daily dose ADD is calculated by the following equation:

$$\text{Soil Ingestion ADD} = [\text{OHM}]_{\text{soil}} \times 10^{-4} \text{ kg/mg} \times \text{RAF}_{\text{ing}} \times \text{NADSIRs}_{-1}$$
- The soil dermal contact ADD is calculated by the following equation:

$$\text{Soil Contact ADD} = [\text{OHM}]_{\text{soil}} \times 10^{-4} \text{ kg/mg} \times \text{RAF}_{\text{derm}} \times \text{NADSCRs}_{-1}$$
- Hazard Quotient = ADD/RfD and Hazard Index = Sum (Hazard Quotients)
- A default value is used for this analyte where none was available from MADEP.

where, NADSIRs₋₁ = 3.1 mg soil/kg-day

where, NADSCRs₋₁ = 28.5 mg soil/kg-day

TABLE D-9. AVERAGE DAILY DOSE AND HAZARD INDEX CALCULATIONS FOR RESIDENTIAL EXPOSURES TO UST1 SOIL, MAXIMUM CONCENTRATIONS

Contaminant of Concern	UST-1 Area Maximum (a)(mg/kg)	Chronic Soil Ingestion Exposure		Chronic Soil Dermal Contact Exposure		Chronic RfD (b) (mg/kg-day)	Chemical-Specific Hazard Quotient		Chemical-Specific Hazard Index
		RAF (b)	ADD (c) (mg/kg-day)	RAF (b)	ADD (d) (mg/kg-day)		Ingestion (c)	Dermal (c)	
TPH (mg/kg)	3880								
C5-C9 aliphatics (1%)	38.80	0.91	1.1E-4	0.5	5.5E-4	0.06	1.8E-3	9.2E-3	1.1E-2
C9-C12 aliphatics (9%)	349.2	0.91	9.9E-4	0.2	2.0E-3	0.6	1.6E-3	3.3E-3	5.0E-3
C9-C10 aromatics (8%)	310.4	0.91	8.8E-4	0.18	1.6E-3	0.03	2.9E-2	5.3E-2	8.2E-2
C9-C18 aliphatics (53%)	2056	0.91	5.8E-3	0.20	1.2E-2	0.6	9.7E-3	2.0E-2	2.9E-2
C19-C36 aliphatics (6%)	232.8	0.91	6.6E-4	0.10	6.6E-4	6.0	1.1E-4	1.1E-4	2.2E-4
C11-C22 aromatics (24%)	931.2	0.91	2.6E-3	0.18	4.8E-3	0.03	8.8E-2	1.6E-1	2.5E-1
VOCs (mg/kg)									
Benzene	0.0062	1	1.9E-8	0.08	1.4E-8	5.00E-03	3.8E-6	2.8E-6	6.7E-6
sec-Butylbenzene	0.058	1 (f)	1.8E-7	0.2 (f)	3.3E-7	0.01	1.8E-5	3.3E-5	5.1E-5
Ethylbenzene	0.12	1	3.7E-7	0.2	6.8E-7	0.1	3.7E-6	6.8E-6	1.1E-5
Xylenes (total)	0.23	1	7.1E-7	0.12	7.9E-7	2	3.6E-7	3.9E-7	7.5E-7
Isopropylbenzene	0.013	1 (f)	4.0E-8	0.2 (f)	7.4E-8	0.1	4.0E-7	7.4E-7	1.1E-6
p-Isopropyltoluene	0.041	1 (f)	1.3E-7	0.2 (f)	2.3E-7	NA	NA	NA	NA
n-Propylbenzene	0.027	1 (f)	8.4E-8	0.2 (f)	1.5E-7	NA	NA	NA	NA
1,2,4-Trimethylbenzene	0.008	1 (f)	2.5E-8	0.2 (f)	4.6E-8	5.00E-02	5.0E-7	9.1E-7	1.4E-6
1,3,5-Trimethylbenzene	0.011	1 (f)	3.4E-8	0.2 (f)	6.3E-8	5.00E-02	6.8E-7	1.3E-6	1.9E-6
SVOCs (mg/kg)									
Acenaphthene	1.4	1	4.3E-6	0.2	8.0E-6	0.06	7.2E-5	1.3E-4	2.1E-4
Acenaphthylene	0.013	0.91	3.7E-8	0.18	6.7E-8	0.04	9.2E-7	1.7E-6	2.6E-6
Anthracene	0.56	1	1.7E-6	0.29	4.6E-6	0.3	5.8E-6	1.5E-5	2.1E-5
Benzo(a)anthracene	0.046	0.91	1.3E-7	0.18	2.4E-7	0.04	3.2E-6	5.9E-6	9.1E-6
Benzo(a)pyrene	0.053	0.91	1.5E-7	0.18	2.7E-7	0.04	3.7E-6	6.8E-6	1.1E-5
Benzo(b)fluoranthene	0.047	0.91	1.3E-7	0.18	2.4E-7	0.04	3.3E-6	6.0E-6	9.3E-6
Benzo(g,h,i)perylene	0.034	0.91	9.6E-8	0.18	1.7E-7	0.04	2.4E-6	4.4E-6	6.8E-6
Benzo(k)fluoranthene	0.057	0.91	1.6E-7	0.18	2.9E-7	0.04	4.0E-6	7.3E-6	1.1E-5
Butylbenzylphthalate	0.032	1 (f)	9.9E-8	0.2 (f)	1.8E-7	0.2	5.0E-7	9.1E-7	1.4E-6
Chrysene	0.074	0.91	2.1E-7	0.18	3.8E-7	0.04	5.2E-6	9.5E-6	1.5E-5
Dibenzo(a,h)anthracene	0.01	0.91	2.8E-8	0.08	2.3E-8	0.04	7.1E-7	5.7E-7	1.3E-6
Dibenzofuran	0.97	1 (f)	3.0E-6	0.2 (f)	5.5E-6	0.004	7.5E-4	1.4E-3	2.1E-3
Di-n-octylphthalate	0.043	1 (f)	1.3E-7	0.2 (f)	2.5E-7	0.02	6.7E-6	1.2E-5	1.9E-5
Fluoranthene	0.16	1	5.0E-7	0.2	9.1E-7	0.04	1.2E-5	2.3E-5	3.5E-5
Fluorene	2	1	6.2E-6	0.2	1.1E-5	0.04	1.6E-4	2.9E-4	4.4E-4
Indeno(1,2,3-cd)pyrene	0.034	0.91	9.6E-8	0.18	1.7E-7	0.04	2.4E-6	4.4E-6	6.8E-6
2-Methylnaphthalene	25	1	7.8E-5	0.1	7.1E-5	0.04	1.9E-3	1.8E-3	3.7E-3
N-Nitrosodiphenylamine	1.8	1 (f)	5.6E-6	0.2 (f)	1.0E-5	NA	NA	NA	NA
Naphthalene	3.9	1	1.2E-5	0.1	1.1E-5	0.04	3.0E-4	2.8E-4	5.8E-4
Phenanthrene	2.2	0.91	6.2E-6	0.18	1.1E-5	0.04	1.6E-4	2.8E-4	4.4E-4
Pyrene	0.15	1	4.7E-7	0.2	8.6E-7	0.03	1.6E-5	2.9E-5	4.4E-5

TOTAL HAZARD INDEX = 0.28

NOTES:

- Concentrations and TPH fraction percentages from Table D-2.
- RfD and RAF values taken from Tables D-6 and D-7, respectively.
- The soil ingestion average daily dose ADD is calculated by the following equation:

$$\text{Soil Ingestion ADD} = [\text{OHM}]_{\text{soil}} * 10^{-6} \text{ kg/mg} * \text{RAF}_{\text{ing}} * \text{NADSIRs}_{-1}$$
- The soil dermal contact ADD is calculated by the following equation:

$$\text{Soil Contact ADD} = [\text{OHM}]_{\text{soil}} * 10^{-6} \text{ kg/mg} * \text{RAF}_{\text{derm}} * \text{NADSCRs}_{-1}$$
- Hazard Quotient = ADD/RfD and Hazard Index = Sum (Hazard Quotients)
- A default value is used for this analyte where none was available from MADEP.

where, NADSIRs₋₁ = 3.1 mg soil/kg-day

where, NADSCRs₋₁ = 28.5 mg soil/kg-day

TABLE D-10. AVERAGE DAILY DOSE AND HAZARD INDEX CALCULATIONS FOR RESIDENTIAL EXPOSURES TO UST2 SOIL, AVERAGE CONCENTRATIONS

Contaminant of Concern	UST-2 Area Average (a) (mg/kg)	Chronic Soil Ingestion Exposure		Chronic Soil Dermal Contact Exposure		Chronic RfD (b) (mg/kg-day)	Chemical-Specific Hazard Quotient		Chemical-Specific Hazard Index
		RAF (b)	ADD (c) (mg/kg-day)	RAF (b)	ADD (d) (mg/kg-day)		Ingestion (e)	Dermal (e)	
TPH (mg/kg)	489								
C5-C9 aliphatics (1%)	4.89	0.91	1.4E-5	0.5	7.0E-5	0.06	2.3E-4	1.2E-3	1.4E-3
C9-C12 aliphatics (9%)	44.0	0.91	1.2E-4	0.2	2.5E-4	0.6	2.1E-4	4.2E-4	6.3E-4
C9-C10 aromatics (8%)	39.1	0.91	1.1E-4	0.18	2.0E-4	0.03	3.7E-3	6.7E-3	1.0E-2
C9-C18 aliphatics (53%)	259	0.91	7.3E-4	0.20	1.5E-3	0.6	1.2E-3	2.5E-3	3.7E-3
C19-C36 aliphatics (6%)	29.3	0.91	8.3E-5	0.10	8.4E-5	6.0	1.4E-5	1.4E-5	2.8E-5
C11-C22 aromatics (24%)	117	0.91	3.3E-4	0.18	6.0E-4	0.03	1.1E-2	2.0E-2	3.1E-2
VOCs (mg/kg)									
2-Butanone (MEK)	0.002	1	6.2E-9	0.1	5.7E-9	0.6	1.0E-8	9.5E-9	2.0E-8
1,1-Dichloroethane	0.002	1.3	8.1E-9	0.13	7.4E-9	0.1	8.1E-8	7.4E-8	1.5E-7
1,1-Dichloroethene	0.002	1	6.2E-9	0.1	5.7E-9	0.009	6.9E-7	6.3E-7	1.3E-6

TOTAL HAZARD INDEX = 0.035

NOTES:

a. Mean concentration from Table D-3; TPH percentages taken from Table D-2.

b. RfD and RAF values taken from Tables D-6 and D-7, respectively.

c. The soil ingestion average daily dose ADD is calculated by the following equation:

Soil Ingestion ADD = $[OHM]_{soil} \cdot 10^{-4} \text{ kg/mg} \cdot RAF_{ing} \cdot NADSIRS_{-1}$

where, $NADSIRS_{-1} = 3.1 \text{ mg soil/kg-day}$

d. The soil dermal contact ADD is calculated by the following equation:

Soil Contact ADD = $[OHM]_{soil} \cdot 10^{-4} \text{ kg/mg} \cdot RAF_{derm} \cdot NADSCRs_{-1}$

where, $NADSCRs_{-1} = 28.5 \text{ mg soil/kg-day}$

e. Hazard Quotient = ADD/RfD and Hazard Index = Sum (Hazard Quotients)

TABLE D-11. AVERAGE DAILY DOSE AND HAZARD INDEX CALCULATIONS FOR RESIDENTIAL EXPOSURES TO UST2 SOIL, MAXIMUM CONCENTRATIONS

Contaminant of Concern	UST-2 Area Maximum (a)(mg/kg)	Chronic Soil Ingestion Exposure		Chronic Soil Dermal Contact Exposure		Chronic RfD (b) (mg/kg-day)	Chemical-Specific Hazard Quotient		Chemical-Specific Hazard Index
		RAF (b)	ADD (c) (mg/kg-day)	RAF (b)	ADD (d) (mg/kg-day)		Ingestion (e)	Dermal (e)	
TPH (mg/kg)	1,100								
C5-C9 aliphatics (1%)	11.00	0.91	3.1E-5	0.5	1.6E-4	0.06	5.2E-4	2.6E-3	3.1E-3
C9-C12 aliphatics (9%)	99.00	0.91	2.8E-4	0.2	5.6E-4	0.6	4.7E-4	9.4E-4	1.4E-3
C9-C10 aromatics (8%)	88.00	0.91	2.5E-4	0.18	4.5E-4	0.03	8.3E-3	1.5E-2	2.3E-2
C9-C18 aliphatics (53%)	583.0	0.91	1.6E-3	0.20	3.3E-3	0.6	2.7E-3	5.5E-3	8.3E-3
C19-C36 aliphatics (6%)	66.00	0.91	1.9E-4	0.10	1.9E-4	6.0	3.1E-5	3.1E-5	6.2E-5
C11-C22 aromatics (24%)	264.0	0.91	7.4E-4	0.18	1.4E-3	0.03	2.5E-2	4.5E-2	7.0E-2
VOCs (mg/kg)									
2-Butanone (MEK)	0.002	1	6.2E-9	0.1	5.7E-9	0.6	1.0E-8	9.5E-9	2.0E-8
1,1-Dichloroethane	0.002	1.3	8.1E-9	0.13	7.4E-9	0.1	8.1E-8	7.4E-8	1.5E-7
1,1-Dichloroethene	0.002	1	6.2E-9	0.1	5.7E-9	0.009	6.9E-7	6.3E-7	1.3E-6

TOTAL HAZARD INDEX = 0.078

NOTES:

a. Concentration from Table D-3; TPH percentages taken from Table D-2.

b. RfD and RAF values taken from Tables D-6 and D-7, respectively.

c. The soil ingestion average daily dose ADD is calculated by the following equation:

$$\text{Soil Ingestion ADD} = [\text{OHM}]_{\text{soil}} * 10^{-6} \text{ kg/mg} * \text{RAF}_{\text{ing}} * \text{NADSIRs-1}$$

$$\text{where, NADSIRs-1} = 3.1 \text{ mg soil/kg-day}$$

d. The soil dermal contact ADD is calculated by the following equation:

$$\text{Soil Contact ADD} = [\text{OHM}]_{\text{soil}} * 10^{-6} \text{ kg/mg} * \text{RAF}_{\text{derm}} * \text{NADSCRs-1}$$

$$\text{where, NADSCRs-1} = 28.5 \text{ mg soil/kg-day}$$

e. Hazard Quotient = ADD/RfD and Hazard Index = Sum (Hazard Quotients)

TABLE D-12. LIFETIME AVERAGE DAILY DOSE AND EXCESS LIFETIME CANCER RISK CALCULATIONS FOR RESIDENTIAL EXPOSURES TO UST1 SOIL, AVERAGE CONCENTRATIONS

Contaminant of Concern	UST-1 Area Average (a) (mg/kg)	Chronic Soil Ingestion Exposure		Chronic Soil Dermal Contact Exposure		Oral Slope Factor (b) /(mg/kg-day)	Excess Lifetime Cancer Risk (ELCR)		Chemical-Specific ELCR (e)
		RAF (b)	LADD (c) (mg/kg-day)	RAF (b)	LADD (d) (mg/kg-day)		Ingestion (c)	Dermal (e)	
TPH (mg/kg)	560	NC	NC	NC	NC	NC			
C5-C9 aliphatics (1%)	5.60	NC	NC	NC	NC	NC			
C9-C12 aliphatics (9%)	50.4	NC	NC	NC	NC	NC			
C9-C10 aromatics (8%)	44.8	NC	NC	NC	NC	NC			
C9-C18 aliphatics (53%)	297	NC	NC	NC	NC	NC			
C19-C36 aliphatics (6%)	33.6	NC	NC	NC	NC	NC			
C11-C22 aromatics (24%)	134	NC	NC	NC	NC	NC			
VOCs (mg/kg)									
Benzene	0.0062	1	2.5E-09	0.08	3.6E-09	2.90E-02	7.4E-11	1.1E-10	1.8E-10
sec-Butylbenzene	0.019	NA	NA	NA	NA	NA			
Ethylbenzene	0.032	NC	NC	NC	NC	NC			
Xylenes (total)	0.038	NC	NC	NC	NC	NC			
Isopropylbenzene	0.012	NC	NC	NC	NC	NC			
p-Isopropyltoluene	0.019	NA	NA	NA	NA	NA			
n-Propylbenzene	0.010	NA	NA	NA	NA	NA			
1,2,4-Trimethylbenzene	0.004	NA	NA	NA	NA	NA			
1,3,5-Trimethylbenzene	0.004	NA	NA	NA	NA	NA			
SVOCs (mg/kg)									
Acenaphthene	0.494	NC	NC	NC	NC	NC			
Acenaphthylene	0.013	NC	NC	NC	NC	NC			
Anthracene	0.272	NC	NC	NC	NC	NC			
Benzo(a)anthracene	0.046	1	1.9E-08	0.2	6.7E-08	0.73	1.4E-8	4.9E-8	6.3E-8
Benzo(a)pyrene	0.053	1	2.2E-08	0.2	7.7E-08	7.3	1.6E-7	5.6E-7	7.2E-7
Benzo(b)fluoranthene	0.047	1	1.9E-08	0.2	6.9E-08	0.73	1.4E-8	5.0E-8	6.4E-8
Benzo(g,h,i)perylene	0.034	NC	NC	NC	NC	NC			
Benzo(k)fluoranthene	0.057	1	2.3E-08	0.2	8.3E-08	0.073	1.7E-9	6.1E-9	7.8E-9
Butylbenzylphthalate	0.032	NA	NA	NA	NA	NA			
Chrysene	0.074	1	3.0E-08	0.2	1.1E-07	0.073	2.2E-9	7.9E-9	1.0E-8
Dibenzo(a,h)anthracene	0.010	1	4.1E-09	0.09	6.6E-09	7.3	3.0E-8	4.8E-8	7.8E-8
Dibenzofuran	0.385	NC	NC	NC	NC	NC			
Di-n-octylphthalate	0.043	NA	NA	NA	NA	NA			
Fluoranthene	0.082	NC	NC	NC	NC	NC			
Fluorene	0.880	NC	NC	NC	NC	NC			
Indeno(1,2,3-cd)pyrene	0.034	1	1.4E-08	0.2	5.0E-08	0.73	1.0E-8	3.6E-8	4.6E-8
2-Methylnaphthalene	4.135	NC	NC	NC	NC	NC			
N-Nitrosodiphenylamine	0.800	1 (f)	3.3E-07	0.2 (f)	1.2E-06	4.90E-03	1.6E-9	5.7E-9	7.3E-9
Naphthalene	0.640	NC	NC	NC	NC	NC			
Phenanthrene	1.112	NC	NC	NC	NC	NC			
Pyrene	0.105	NC	NC	NC	NC	NC			

TOTAL ELCR (e) = 1.0E-6

NOTES:

a. Mean concentrations and TPH percentages from Table D-2.

b. Slope Factors and RAF values taken from Tables D-6 and D-7, respectively.

c. The soil ingestion lifetime average daily dose (LADD) is calculated by the following equation:

Soil Ingestion LADD = [OHM]_{soil} * 10⁻⁴ kg/mg * RAF_{ing} * NLADSIRs₋₁ where, NLADSIRs₋₁ = 0.41 mg soil/kg-day

d. The soil dermal contact LADD is calculated by the following equation:

Soil Contact LADD = [OHM]_{soil} * 10⁻⁴ kg/mg * RAF_{derm} * NLADSCRs₋₁ where, NLADSCRs₋₁ = 7.3 mg soil/kg-day

e. Excess Lifetime Cancer Risk (ELCR) = LADD*SF and Total ELCR = Sum (Chemical-Specific ELCR)

f. A default value is used for this analyte where none was available from MADEP.

TABLE D-13. LIFETIME AVERAGE DAILY DOSE AND EXCESS LIFETIME CANCER RISK CALCULATIONS FOR RESIDENTIAL EXPOSURES TO UST1 SOIL, MAXIMUM CONCENTRATIONS

Contaminant of Concern	UST-1 Area Average (a) (mg/kg)	Chronic Soil Ingestion Exposure		Chronic Soil Dermal Contact Exposure		Oral Slope Factor (b) /(mg/kg-day)	Excess Lifetime Cancer Risk (ELCR)		Chemical-Specific ELCR (e)
		RAF (b)	LADD (c) (mg/kg-day)	RAF (b)	LADD (d) (mg/kg-day)		Ingestion (c)	Dermal (e)	
TPH (mg/kg)	3880								
C5-C9 aliphatics (1%)	38.80	NC	NC	NC	NC	NC			
C9-C12 aliphatics (9%)	349.2	NC	NC	NC	NC	NC			
C9-C10 aromatics (8%)	310.4	NC	NC	NC	NC	NC			
C9-C18 aliphatics (53%)	2056	NC	NC	NC	NC	NC			
C19-C36 aliphatics (6%)	232.8	NC	NC	NC	NC	NC			
C11-C22 aromatics (24%)	931.2	NC	NC	NC	NC	NC			
VOCs (mg/kg)									
Benzene	0.0062	1	2.5E-09	0.08	3.6E-09	2.90E-02	7.4E-11	1.1E-10	1.8E-10
sec-Butylbenzene	0.058	NA	NA	NA	NA	NA			
Ethylbenzene	0.12	NC	NC	NC	NC	NC			
Xylenes (total)	0.23	NC	NC	NC	NC	NC			
Isopropylbenzene	0.013	NC	NC	NC	NC	NC			
p-Isopropyltoluene	0.041	NA	NA	NA	NA	NA			
n-Propylbenzene	0.027	NA	NA	NA	NA	NA			
1,2,4-Trimethylbenzene	0.008	NA	NA	NA	NA	NA			
1,3,5-Trimethylbenzene	0.011	NA	NA	NA	NA	NA			
SVOCs (mg/kg)									
Acenaphthene	1.4	NC	NC	NC	NC	NC			
Acenaphthylene	0.013	NC	NC	NC	NC	NC			
Anthracene	0.56	NC	NC	NC	NC	NC			
Benzo(a)anthracene	0.046	1	1.9E-08	0.2	6.7E-08	0.73	1.4E-8	4.9E-8	6.3E-8
Benzo(a)pyrene	0.053	1	2.2E-08	0.2	7.7E-08	7.3	1.6E-7	5.6E-7	7.2E-7
Benzo(b)fluoranthene	0.047	1	1.9E-08	0.2	6.9E-08	0.73	1.4E-8	5.0E-8	6.4E-8
Benzo(g,h,i)perylene	0.034	NC	NC	NC	NC	NC			
Benzo(k)fluoranthene	0.057	1	2.3E-08	0.2	8.3E-08	0.073	1.7E-9	6.1E-9	7.8E-9
Butylbenzylphthalate	0.032	NA	NA	NA	NA	NA			
Chrysene	0.074	1	3.0E-08	0.2	1.1E-07	0.073	2.2E-9	7.9E-9	1.0E-8
Dibenzo(a,h)anthracene	0.01	1	4.1E-09	0.09	6.6E-09	7.3	3.0E-8	4.8E-8	7.8E-8
Dibenzofuran	0.97	NC	NC	NC	NC	NC			
Di-n-octylphthalate	0.043	NA	NA	NA	NA	NA			
Fluoranthene	0.16	NC	NC	NC	NC	NC			
Fluorene	2	NC	NC	NC	NC	NC			
Indeno(1,2,3-cd)pyrene	0.034	1	1.4E-08	0.2	5.0E-08	0.73	1.0E-8	3.6E-8	4.6E-8
2-Methylnaphthalene	25	NC	NC	NC	NC	NC			
N-Nitrosodiphenylamine	1.8	1 (f)	7.4E-07	0.2 (f)	2.6E-06	4.90E-03	3.6E-9	1.3E-8	1.6E-8
Naphthalene	3.9	NC	NC	NC	NC	NC			
Phenanthrene	2.2	NC	NC	NC	NC	NC			
Pyrene	0.15	NC	NC	NC	NC	NC			

TOTAL ELCR (e) = 1.0E-6

NOTES:

a. Concentrations and TPH percentages from Table D-2.

b. Slope Factors and RAF values taken from Tables D-6 and D-7, respectively.

c. The soil ingestion lifetime average daily dose (LADD) is calculated by the following equation:

Soil Ingestion LADD = $[\text{OHM}]_{\text{soil}} \times 10^{-6} \text{ kg/mg} \times \text{RAF}_{\text{ing}} \times \text{NLADSIRs}_{-1}$ where, $\text{NLADSIRs}_{-1} = 0.41 \text{ mg soil/kg-day}$

d. The soil dermal contact LADD is calculated by the following equation:

Soil Contact LADD = $[\text{OHM}]_{\text{soil}} \times 10^{-6} \text{ kg/mg} \times \text{RAF}_{\text{derm}} \times \text{NLADSCRs}_{-1}$ where, $\text{NLADSCRs}_{-1} = 7.3 \text{ mg soil/kg-day}$

e. Excess Lifetime Cancer Risk (ELCR) = LADD*SF and Total ELCR = Sum (Chemical-Specific ELCR)

f. A default value is used for this analyte where none was available from MADEP.

TABLE D-14. LIFETIME AVERAGE DAILY DOSE AND EXCESS LIFETIME CANCER RISK CALCULATIONS FOR RESIDENTIAL EXPOSURES TO UST2 SOIL, AVERAGE CONCENTRATIONS

Contaminant of Concern	UST-2 Area Average (a) (mg/kg)	Chronic Soil Ingestion Exposure		Chronic Soil Dermal Contact Exposure		Slope Factor (b) /(mg/kg-day)	Chemical-Specific Excess Lifetime Cancer Risk (ELCR)		Chemical-Specific ELCR (e)
		RAF (b)	LADD (c) (mg/kg-day)	RAF (b)	LADD (d) (mg/kg-day)		Ingestion (e)	Dermal (e)	
TPH (mg/kg)	489								
C5-C9 aliphatics (1%)	4.89	NC	NC	NC	NC	NC	NC	NC	NC
C9-C12 aliphatics (9%)	44.0	NC	NC	NC	NC	NC	NC	NC	NC
C9-C10 aromatics (8%)	39.1	NC	NC	NC	NC	NC	NC	NC	NC
C9-C18 aliphatics (53%)	259	NC	NC	NC	NC	NC	NC	NC	NC
C19-C36 aliphatics (6%)	29.3	NC	NC	NC	NC	NC	NC	NC	NC
C11-C22 aromatics (24%)	117	NC	NC	NC	NC	NC	NC	NC	NC
VOCs (mg/kg)									
2-Butanone (MEK)	0.002	NC	NC	NC	NC	NC	NC	NC	NC
1,1-Dichloroethane	0.002	NC	NC	NC	NC	NA	NA	NA	NA
1,1-Dichloroethene	0.002	1.02	6.3E-9	0.102	5.8E-9	0.6	1.1E-8	9.7E-9	2.0E-8

TOTAL ELCR (e) = 2.0E-8

NOTES:

a. Mean concentrations from Table D-3; TPH percentages from Table D-2.

b. Slope Factors and RAF values taken from Tables D-6 and D-7, respectively.

c. The soil ingestion lifetime average daily dose (LADD) is calculated by the following equation:

Soil Ingestion LADD = $[\text{OHM}]_{\text{soil}} \times 10^{-6} \text{ kg/mg} \times \text{RAF}_{\text{ing}} \times \text{NLADSIRs-1}$ where, $\text{NADSIRs-1} = 3.1 \text{ mg soil/kg-day}$

d. The soil dermal contact LADD is calculated by the following equation:

Soil Contact LADD = $[\text{OHM}]_{\text{soil}} \times 10^{-6} \text{ kg/mg} \times \text{RAF}_{\text{derm}} \times \text{NLADSCRs-1}$ where, $\text{NADSCRs-1} = 28.5 \text{ mg soil/kg-day}$

e. Excess Lifetime Cancer Risk (ELCR) = LADD*SF and Total ELCR = Sum (Chemical-Specific ELCR)

TABLE D-15. LIFETIME AVERAGE DAILY DOSE AND EXCESS LIFETIME CANCER RISK CALCULATIONS FOR RESIDENTIAL EXPOSURES TO UST2 SOIL, MAXIMUM CONCENTRATIONS

Contaminant of Concern	UST-2 Area Maximum (a)(mg/kg)	Chronic Soil Ingestion Exposure		Chronic Soil Dermal Contact Exposure		Slope Factor (b) / (mg/kg-day)	Chemical-Specific Excess Lifetime Cancer Risk (ELCR)		Chemical-Specific ELCR (e)
		RAF (b)	LADD (c) (mg/kg-day)	RAF (b)	LADD (d) (mg/kg-day)		Ingestion (e)	Dermal (e)	
TPH (mg/kg)	1,100								
C5-C9 aliphatics (1%)	11.0	NC	NC	NC	NC	NC	NC	NC	NC
C9-C12 aliphatics (9%)	99.0	NC	NC	NC	NC	NC	NC	NC	NC
C9-C10 aromatics (8%)	88.0	NC	NC	NC	NC	NC	NC	NC	NC
C9-C18 aliphatics (53%)	583	NC	NC	NC	NC	NC	NC	NC	NC
C19-C36 aliphatics (6%)	66.0	NC	NC	NC	NC	NC	NC	NC	NC
C11-C22 aromatics (24%)	264	NC	NC	NC	NC	NC	NC	NC	NC
VOCs (mg/kg)									
2-Butanone (MEK)	0.002	NC	NC	NC	NC	NC	NC	NC	NC
1,1-Dichloroethane	0.002	NC	NC	NC	NC	NA	NA	NA	NA
1,1-Dichloroethene	0.002	1.02	6.3E-9	0.102	5.8E-9	0.6	1.1E-8	9.7E-9	2.0E-8

TOTAL ELCR (e) = 2.0E-8

NOTES:

- Concentrations from Table D-3; TPH percentages from Table D-2.
- Slope Factors and RAF values taken from Tables D-6 and D-7, respectively.
- The soil ingestion lifetime average daily dose (LADD) is calculated by the following equation:

$$\text{Soil Ingestion LADD} = [\text{OHM}]_{\text{soil}} \cdot 10^{-4} \text{ kg/mg} \cdot \text{RAF}_{\text{ing}} \cdot \text{NLADSIRs-1}$$
where, $\text{NADSIRs-1} = 3.1 \text{ mg soil/kg-day}$
- The soil dermal contact LADD is calculated by the following equation:

$$\text{Soil Contact LADD} = [\text{OHM}]_{\text{soil}} \cdot 10^{-4} \text{ kg/mg} \cdot \text{RAF}_{\text{derm}} \cdot \text{NLADSCRs-1}$$
where, $\text{NADSCRs-1} = 28.5 \text{ mg soil/kg-day}$
- Excess Lifetime Cancer Risk (ELCR) = LADD*SF and Total ELCR = Sum (Chemical-Specific ELCR)

**TABLE D-16. SUMMARY OF POTENTIAL RISKS UNDER
THE FUTURE RESIDENT SCENARIO**

	Risks from Residential Exposure to Soil (a)	
	Hazard Index (b)	Excess Lifetime Cancer Risk (c)
FOR UST-1 AREA:		
Average Concentrations	0.04	1×10^{-6}
Maximum Concentrations	0.28	1×10^{-6}
FOR UST-2 AREA:		
Average Concentrations	0.035	2×10^{-8}
Maximum Concentrations	0.078	2×10^{-8}

NOTES:

- a. No risk estimate exceeds MADEP risk limits of one for hazard indices and 1×10^{-5} for excess lifetime cancer risk (ELCR).
- b. Hazard Indices taken from Tables D-8 through D-11.
- c. Excess Lifetime Cancer Risks taken from Tables D-12 through D-15.

**TABLE D-17. MAXIMUM GROUNDWATER CONCENTRATIONS COMPARED TO
GW-3 STANDARDS**

Contaminant of Concern	<u>Groundwater Concentrations (ug/L)</u>		GW-3 Standard for Groundwater (c) (ug/L)
	10% of UST-1 Area (a)	10% of UST-2 Area (b)	
	Maximum	Maximum	
VOCs (ug/L)			
1,1-Dichloroethane	0.06	1.9	50,000
1,1-Dichloroethene	ND	0.5	50,000
1,1,1-Trichloroethane	0.07	13	50,000
Trichloroethene	0.1	2	20,000

NOTES:

- a. See Table D-4 for data.
- b. See Table D-5 for data.
- c. No groundwater concentrations detected at the site exceeded any GW-3 standards.

NA - Not analyzed

TABLE D-18. EXPOSURE POINT CONCENTRATIONS FOR SOILS COMPARED TO UPPER CONCENTRATION LIMITS (UCLs)

Contaminant of Concern (mg/kg)	UST-1 Area (a)		UST-2 Area (b)		UCLs for Soil (c)
	Maximum	Average	Maximum	Average	
TPH (mg/kg)	3,880	560	1,100	489	10,000
C5-C9 aliphatics (1%)	38.8	5.6	11.0	4.9	5,000
C9-C12 aliphatics (9%)	349	50	99.0	44	20,000
C9-C10 aromatics (8%)	310	45	88.0	39	5,000
C9-C18 aliphatics (53%)	2056	297	583	259	20,000
C19-C36 aliphatics (6%)	233	34	66.0	29	20,000
C11-C22 aromatics (24%)	931	134	264	117	10,000
VOCs (mg/kg)					
Benzene	0.0062	0.0062 *	NA	NA	2,000
2-Butanone	NA	NA	0.002	0.002	10,000
sec-Butylbenzene	0.058	0.019	NA	NA	NA
1,1-Dichloroethane	NA	NA	0.002	0.002	5,000
1,1-Dichloroethene	NA	NA	0.002	0.002	90
Ethylbenzene	0.12	0.032	NA	NA	10,000
Isopropylbenzene	0.013	0.012	NA	NA	NA
p-Isopropyltoluene	0.041	0.019	NA	NA	NA
Naphthalene	0.2	0.065	NA	NA	10,000
n-Propylbenzene	0.027	0.010	NA	NA	NA
1,2,4-Trimethylbenzene	0.008	0.0039	NA	NA	NA
1,3,5-Trimethylbenzene	0.011	0.0043	NA	NA	NA
Xylenes (total)	0.23	0.038	NA	NA	10,000
SVOCs (mg/kg)					
Acenaphthene	1.4	0.49	NA	NA	10,000
Acenaphthylene	0.013	0.013 *	NA	NA	10,000
Anthracene	0.56	0.27	NA	NA	10,000
Benzo(a)anthracene	0.046	0.046 *	NA	NA	7
Benzo(a)pyrene	0.053	0.053 *	NA	NA	7
Benzo(b)fluoranthene	0.047	0.047 *	NA	NA	7
Benzo(g,h,i)perylene	0.034	0.034 *	NA	NA	10,000
Benzo(k)fluoranthene	0.057	0.057 *	NA	NA	7
Butylbenzylphthalate	0.032	0.032 *	NA	NA	NA
Chrysene	0.074	0.074 *	NA	NA	7
Dibenzo(a,h)anthracene	0.01	0.01 *	NA	NA	8
Dibenzofuran	0.97	0.39	NA	NA	NA
Di-n-octylphthalate	0.043	0.043 *	NA	NA	NA
Fluoranthene	0.16	0.082	NA	NA	10,000
Fluorene	2	0.88	NA	NA	10,000
Indeno(1,2,3-cd)pyrene	0.034	0.034 *	NA	NA	7
2-Methylnaphthalene	25	4.1	NA	NA	10,000
N-Nitrosodiphenylamine	1.8	0.80	NA	NA	NA
Naphthalene	3.9	0.64	NA	NA	10,000
Phenanthrene	2.2	1.11	NA	NA	10,000
Pyrene	0.15	0.105	NA	NA	10,000

NOTES:

- See Table D-2 for data.
- See Table D-3 for data.
- No soil concentrations detected at the site exceeded any UCLs.

NA - Not analyzed

* - Maximum detected concentration is provided; mean concentration was greater than the maximum detected due to elevated detection limits.

TABLE D-19. MAXIMUM GROUNDWATER CONCENTRATIONS COMPARED TO UPPER CONCENTRATION LIMITS (UCLs)

Contaminant of Concern	Groundwater Concentrations (ug/L)		UCLs for Groundwater (c) (ug/L)
	UST-1 Area (a) Maximum	UST-2 Area (b) Maximum	
VOCs (ug/L)			
1,1-Dichloroethane	0.6	19	100,000
1,1-Dichloroethene	ND	5	100,000
1,1,1-Trichloroethane	0.7	130	100,000
Trichloroethene	1	20	100,000

NOTES:

- a. See Table D-4 for data.
- b. See Table D-5 for data.
- c. No groundwater concentrations detected at the site exceeded any UCLs.

NA - Not analyzed

ND - Not Detected

Table D-20. Ecological Effects-Based Screening for Groundwater

Parameter	Maximum Concentration ¹	Well	Date	Adjusted Maximum ²	AWQC ³	AWQC Type
TPH (ug/L)	91,000	B-4	1991	9,100	20,000	GW-3 standard ⁴
Chlorinated VOCs (ug/L)						
1,1-Dichloroethene	19	MW-9	1996	1.9	11600	Acute (LOEL)
1,1-Dichloroethane	5	MW-9	1996	0.5	NA	
1,1,1-Trichloroethane	130	MW-9	1996	13.0	18000	Acute (LOEL)
Trichloroethene	20	MW-9	1996	2.0	21900	Chronic (LOEL)
Methylene chloride	3	MW-9	1996	0.3	NA	

NA - Not Available

LOEL - Lowest Observed Effect Level

Bold text indicates diluted concentration exceeds effects-based screening criterion.

¹ For chlorinated VOC's, concentration detected in MW-9.

For TPH, concentration is highest detected at site.

² Concentration was multiplied by a dilution/attenuation factor of 10.

³ AWQC are freshwater chronic or acute AWQC or LOELs.

⁴ MCP Method I GW-3 standard

APPENDIX E
LABORATORY ANALYTICAL DATA
(BOUND SEPARATELY)